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Minerals Yearbook

1976

Volume I

METALS, MINERALS, AND FUELS

Prepared by staff of the

BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR • Cecil D. Andrus, Secretary

BUREAU OF MINES • Roger A. Markle, Director

As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities to protect and conserve our land and water, energy and minerals, fish and wildlife, and park and recreation areas, and for the wise use of all those resources. The Department also has a major responsibility for American Indian reservation communities and for the people who live in Island Territories under U.S. administration.

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Foreword

The Federal Government, through the Minerals Yearbook and its predecessor volumes, has reported annually on mineral industry activities for 95 years. This edition discusses the performance of the worldwide mineral industry during 1976. In addition to statistical data, the volumes provide background information to assist in interpreting the year's developments. Content of the individual volumes follows:

Volume I, Metals, Minerals, and Fuels, contains chapters on virtually all metallic, nonmetallic, and mineral fuel commodities important to the domestic economy. In addition, it includes a general review chapter on the mineral industries, a chapter on mining and quarrying trends, and a statistical summary.

Volume II, Area Reports: Domestic, contains chapters on the mineral industry of each of the 50 States, the U.S. island possessions in the Pacific Ocean and the Caribbean Sea, and the Commonwealth of Puerto Rico. This volume also has a statistical summary, identical to that in Volume I.

Volume III, Area Reports: International, contains the latest available mineral data on more than 130 foreign countries and discusses the importance of minerals to the economies of these nations. A separate chapter reviews the international minerals industry in general and its relationship to the world economy.

The Bureau of Mines continually strives to improve the value of its publications to its users. Therefore, the constructive comments and suggestions of readers of the Yearbook will be welcomed.

Roger A. Markle, Director

Acknowledgments

Volume I, Metals, Minerals, and Fuels, of the Minerals Yearbook presents data on more than 90 mineral commodities that was obtained as a result of the mineral information gathering activities of the Associate Directorate—Mineral and Materials Supply/Demand Analysis.

The collection, compilation, and analysis of data on the domestic minerals and mineral fuel industries were performed by the staffs of the Divisions of Ferrous Metals, Nonferrous Metals, and Nonmetallic Minerals, Assistant Directorate—Metals, Minerals and Materials; the Divisions of Coal, Petroleum and Natural Gas, and Fuels Data, Assistant Directorate—Fuels (now in the Department of Energy); and the Division of Economic Analysis, Assistant Directorate—Interindustry and Economic Analysis. Statistical data were compiled from information supplied by mineral producers, processors, and users in response to production and consumption canvasses, and their voluntary response is gratefully appreciated. The information obtained from individual firms by means of confidential surveys has been grouped to provide statistical aggregates. Data on individual firms are presented only if available from published or other nonconfidential sources or when permission of the companies has been granted. Other material appearing in this volume was obtained from the trade and technical press, industry contacts, and numerous other sources.

Statistics on U.S. imports and exports, world production, and foreign country trade were compiled in the Office of Technical Data Services. U.S. foreign trade data were obtained from reports of the Bureau of the Census, U.S. Department of Commerce. World production and international trade data came from numerous sources, including reports from the Foreign Service, U.S. Department of State.

The Office of Technical Data Services also provided general guidance on the preparation and coordination of the chapters in this volume and reviewed the manuscripts to insure statistical consistency among the tables, figures, and text, between this volume and other volumes, and between this edition and those of former years.

Acknowledgment is also particularly made of the splendid cooperation of the business press, trade associations, scientific journals, international organizations, and other Federal agencies that supplied information.

The Bureau of Mines has been assisted in collecting mine production data and supporting information by numerous cooperating State agencies. These organizations are listed in the acknowledgments to Volume II.

Albert E. Schreck, *Editor-in-Chief*

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Review of the Mineral Industries

By Barry W. Klein,[1] David C. Huttenlock,[1] Mary Ann Good,[2] and Kenneth P. Hanks[1]

The U.S. economy was considerably stronger in 1976 than in 1974 or 1975. Real gross national product (GNP) rose sharply in the first quarter of 1976 and then increased at a more moderate rate for the remainder of the year. The unemployment rate fell until June and then increased for most of the remainder of the year, finishing at the same rate as it had started the year. The inflation rate continued to decline in 1976. Reasons for the relatively low rate (compared with those of 1974 and 1975) included small increases in food prices and only moderate increases in energy prices.

Total U.S. output measured in terms of GNP increased 11.6% in 1976. Real GNP in 1972 constant dollars rose 6.2%. Inflation as measured by the implicit price deflator increased 5.1%. In real terms, gross private domestic investment for residential structures rose 22.7% in 1976 after declining 14.7% in 1975; State and local Government expenditures increased 1.4% in 1976; and personal consumption expenditures for services rose 4.5%. The Federal Reserve Board (FRB) index of industrial production increased 10.2%.

In 1976 the unemployment rate dropped to 7.7%, declining from a 34-year high in 1975 of 8.5%. The number of people employed rose during the year at a greater rate than the increase in the total labor force, causing the fall in unemployment. The unemployment rate began and ended the year at 7.8%, declining to a low of 7.3% in May.

The consumer price index (CPI) rose 5.8% in 1976, much less than in 1974 or 1975. Contributing to the small increase in the CPI relative to proceeding years was the decline in food prices in the first part of 1976, and an increase of only 3.1% for the year as a whole. Energy prices also dropped in the first part of 1976, largely as a result of removal of the tariff on oil and the initial price rollback stipulations of the Energy Policy and Conservation Act. All nonfood commodities rose 5.0% for the year. The wholesale price index rose at the moderate rate of 4.6% in 1976. Farm products and processed foods and feed declined 0.6% (farm products by themselves rose 2.4%), and industrial commodities increased 6.3%. As noted above, the implicit price deflator rose 5.1% in 1976.

U.S. monetary policy in 1976 changed little from that in 1975. Faced with continuing high unemployment and relatively high inflation, the FRB sought to help create financial conditions that would facilitate a sustainable economic recovery while at the same time tending to lower inflation. The money supply M1, defined as currency plus demand deposits, grew 5.8% in 1976 up from 4.1% in 1975. M2, defined as M1 plus time and savings deposits, rose 11.3% in 1976 as compared with 8.5% in 1975.

Fiscal policy in 1976 attempted to maintain the same amount of stimulus as in 1975 for a moderate, sustained expansion of the economy. However, fiscal policy unintentionally became less expansionary in the first half of 1976, when expenditures were less than expected while receipts remained near predicted levels. The deceleration in Federal expenditures, which continued the shift away from defense and toward domestic programs in 1976, was primarily a result of much smaller increases in transfer payments to individuals and grants-in-aid to State and local Governments.

U.S. imports were estimated to be $14.2

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[1]Economist, Division of Economic Analysis.
[2]Statistical assistant, Division of Economic Analysis.

billion higher than exports in 1976. Imports exceeded exports for fuels by an estimated $29.1 billion and for minerals and metals by $4.4 billion. Exports of manufactured products and agricultural products were an estimated $16 billion and $12.5 billion greater than imports, respectively.

Federal activities in areas that affected the mineral industries in 1976 included both continuing and special actions. The Federal Government enacted legislation making the first major revision of the tax code in 7 years and continued to take actions to fight inflation. The subjects of mineral-related laws passed in 1976 included energy, the environment, water, public lands, health and safety, taxes, tariffs, and transportation. Energy legislation was aimed, among other things, at increasing U.S. energy supplies and conserving oil and gas.

Bureau of Mines research programs in 1976 continued to be directed toward improving mineral technology leading to more efficient, less costly extraction; improving the health and safety of miners; increasing the recovery of secondary resources; and minimizing environmental degradation.

Total energy use in the United States rose 4.8% in 1976, in contrast to decreases in 1974 and 1975. As a result of increased economic activity and colder weather, consumption increased for all energy sources except hydropower, which declined due to the Western drought. The household and commercial sector showed the greatest increase of all major consuming sectors. Petroleum (including natural gas liquids) continued to be the Nation's largest energy source, accounting for 47.2% of consumption.

In 1976, the mining industry continued to face environmental regulation problems and higher employment, capital, and operating costs. Cost increases, in some cases, have not been as high as in previous years. Also, firms tried to reduce adverse effects through improved operating methods and better cost controls, and less frequently by curtailing operations. Certain industries, such as lead and aluminum, showed considerable market strength, while others, including zinc and copper, were weak.

The world economy continued to recover in 1976 from the 1974-75 recession, which had been the worst downturn in the post-World War II era. The recovery was largely a result of economic expansions in the United States, West Germany, and Japan. Inflation rates remained high in the face of considerable excess productive capacity and stable or, in some cases, increasing unemployment rates; inflation was, however, somewhat below that of 1974 and 1975.

SOURCES AND USES

ALL MINERALS

Production.—Domestic crude mineral production in 1976 was valued at $69.2 billion, an increase of 11% compared with 1975. Metals production rose 17%, nonmetals increased 11%, and mineral fuels advanced 10%. In constant 1967 dollars total crude mineral output increased just under 1% to $24.8 billion; metals increased 8.3%, and nonmetals rose 5.4%, but mineral fuels declined 1.6%. Shifting back to current dollars, exports of mineral raw materials declined 8.5% to $4.3 billion, and crude mineral imports, over 90% of which consisted of fuels, increased 34.2% to $30.5 billion in 1976.

The FRB index of industrial production (1967=100) for all industries rose 9.8% in 1976 to 129.4 index points. The average for all mining increased 1.2% to 114.1 index points. The average index of production for metal, stone, and earth minerals rose 9.3% to 120.1 index points. The metal index rose 6% and the stone and earth minerals index increased 10.6%. The average index of production for coal, oil, and gas increased 6.6% to 112.8 index points. Individual fuel indexes changed in a mixed pattern: Coal rose 3%, crude oil declined 3%, and natural gas decreased 1.6%.

In the manufacturing sector, production of metals and nonmetals, as shown by the FRB index, rose significantly in 1976. The primary metals index rose 12%, the iron and steel index rose 9%, and the nonferrous metals and products and clay, glass, and stone products indexes both increased more than 15%.

The FRB monthly index for all mining during January was 113.6 index points, a 6% increase over the previous month in 1975. The all mining index decreased to a low of 112.5 index points in July, then

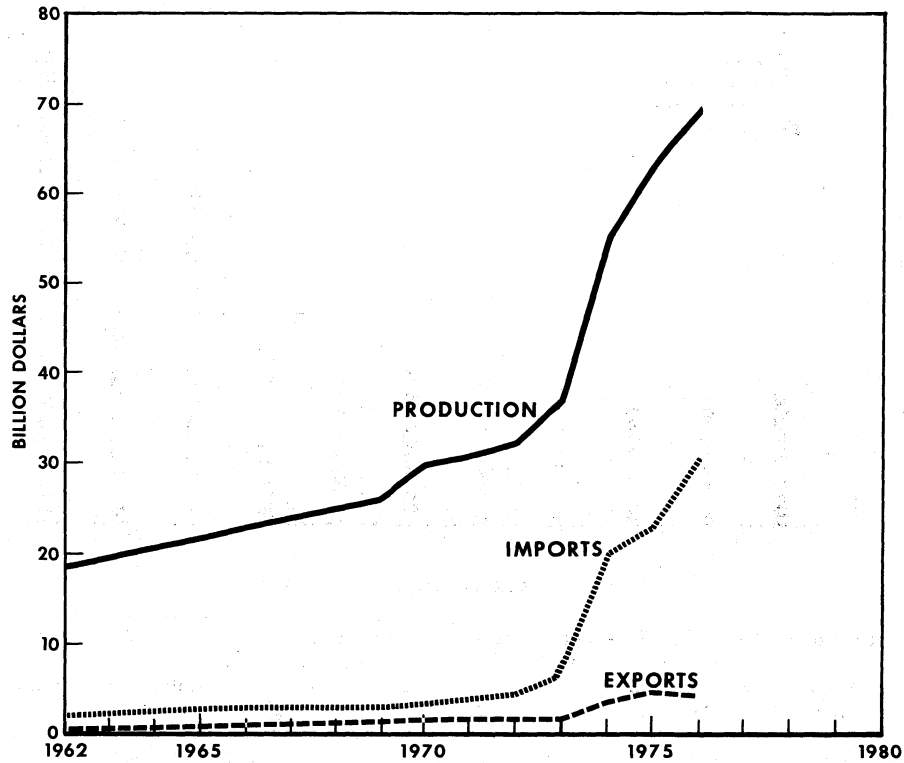

Figure 1.—Value of raw mineral production, exports, and imports.

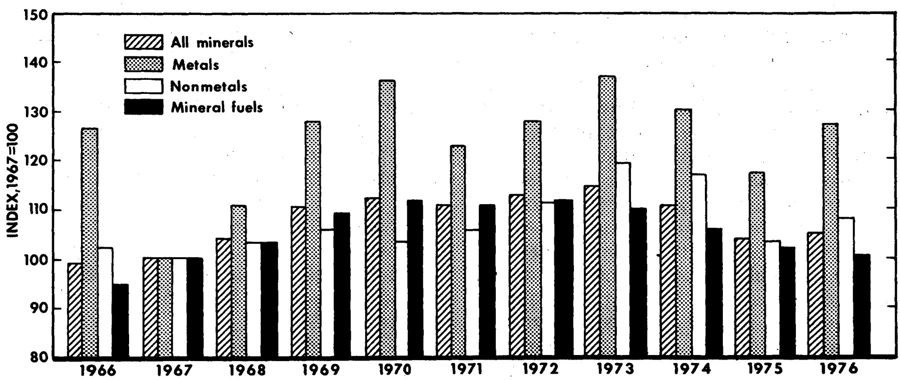

Figure 2.—Indexes of physical volume of mineral production in the United States, by group.

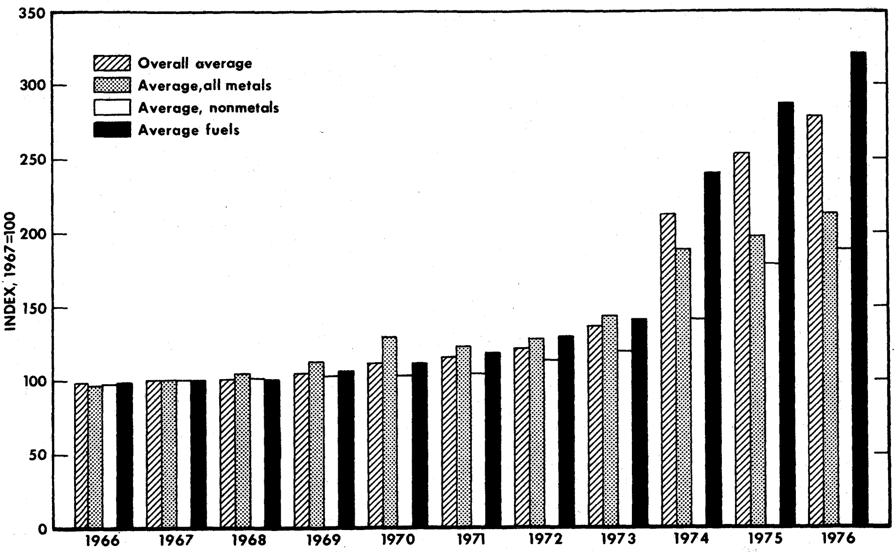

Figure 3.—Indexes of implicit unit value.

increased to 114.4 points in August. There was a continued increase for the remainder of the year finishing at 116.2 index points in December. The coal, oil, and gas index followed the same general trend; coal, although it vacillated due to strikes in the middle of the year, increased 13% over the 12-month period, ending the year at 125.9 index points in December. The oil and gas extraction total index followed the general trend of all mining while the crude oil index started at 94.8 index points in January and decreased to 91.5 index points by December. The metal, stone, and earth minerals and the metal mining index declined in the first half of the year, the lowest point being reached during June after which the index recovered to have an overall increase for the year. Metal mining increased a total of 7% for the year while stone and earth minerals increased by 0.7% for the year.

The net supply of most principal nonfuel minerals increased in 1976. The net supply pattern was mixed for the ferrous metals category. The largest increase within this category was 77% for cobalt followed by 20% for molybdenum, and the largest decline was 12% for tungsten. Iron ore fell 1.4%, but pig iron increased 9.3%, and steel ingot increased 9.8%. Nickel rose 1.8%, chromite declined 2.6%, and manganese declined 7.1%. The net supply of all nonferrous metals, except for tin and ilmenite and slag, increased (excluding metals for which data were not available). Cadmium increased 100% and uranium concentrate rose 54%, but both of these high percentage increases reflect relatively low base figures. Platinum-group metals increased 45.1% and zinc rose 30%. Copper, antimony, and mercury showed increases in the range of 16.7% to 22.4%. Aluminum increased 14% and lead rose 11.5%. Tin declined 3.6% and ilmenite and slag declined 3.2%. The net supply of all but three nonmetals increased. Asbestos increased 20.6%, followed by potash at 20.3%, and gypsum at 14.3%. Sand and gravel, common salt, and crude barite increased in the range of 9.6% to 12.1%. Bromine and clays increased 7.9% and 7.7% respectively. Phosphate rock and talc and allied minerals rose 6.5% and 4.7%, respectively. Sulfur increased 1.6%, mica experienced no change, crushed stone declined a negligible amount, and finished fluorspar showed the only significant decline at 9.3%.

Stocks and Government Stockpiles.—Stocks of crude nonfuel minerals at primary producers at yearend as shown by Bureau of Mines indexes (1967=100), increased for all but one category in 1976. The total index rose 11.9%, the crude metals index increased 12.1%, and the crude nonmetals index increased 11.7%. Within the metals sector, the iron ore index rose 13.7%, the other ferrous index declined 13.5%, and the nonferrous index showed the largest increase of any category at 29.1%. Stocks at mineral manufacturer, consumer, and dealer locations as illustrated by Bureau indexes, unlike those stocks held by primary producers, declined for all categories except one in 1976. The overall index dropped less than 1%, the metals index declined 1.5%, and the nonmetals index decreased 7.7%. Within the metals sector, the iron stock index increased 8.6%, base nonferrous declined less than 1%, other nonferrous fell 4.5%, and other ferrous showed the largest decline at 15.9%.

Producer stocks of bituminous coal and lignite increased 5.2% during 1976; coke increased 29.8%, the largest increase for the reported 1976 stocks. Natural gasoline, plant condensates, and isopentane stocks increased by 10.1%, and crude petroleum, by 5.2%. Other physical stocks that increased in 1976 were special naphthas at 1.5% and the other products category, under crude petroleum and petroleum products, at 2.7%. The overall category of crude petroleum and petroleum products decreased 1.9% and within this category petroleum asphalt had the greatest decline at 15.0% followed by the distillate fuel oil stock down 10.9%; liquefied gases decreased 7.1%; residual fuel oil down 2.4%; and the motor gasoline stock down 1.5%. Also down for 1976 were the carbon black stocks at 7.8% and the natural gas category at 3.7%. The overall trend showed coal and related products with increased physical stocks and the petroleum and related products, in general, with decreased stocks.

The seasonally adjusted book value of product inventories increased for all selected mineral processing industries during 1976. Petroleum and coal products rose by 9.3% to $5,148 million as of December 1976. Stone, clay, and glass products increased by 9% to $4,194 million. Inventories of total primary metals rose 11.6% to $17,329 million. Blast furnace and steel mill inventories rose by 20% to $10,179 million, the largest increase of any category. All other primary metals increased 1.5% to $7,150 million. The total seasonally adjusted book value of inventories for selected mineral processing industries rose 10.7% to $26,671 million during 1976.

The U.S. stockpile of strategic and critical materials continued to represent a significant portion of the Nation's mineral supply in 1976. Minerals in the stockpile as of yearend 1976 that had high total values included antimony, bauxite, chromium, cobalt, industrial diamond, fluorspar, lead, manganese, platinum-group metals, silver, tin, tungsten, and zinc.

Exports.—The total value of selected minerals and mineral products exported in 1976 decreased 7%. Exports in all but two sectors declined. Exports of crude nonmetallic minerals fell 11.2%; those of crude and scrap metals decreased 5.3%; mineral energy resources and related products declined 5.9%; and manufactured metals dropped 18.1%. Iron or steel tubes, pipes, fittings, the largest export value in the manufactured metals category, declined 45%. Those sectors that showed higher export values in 1976 included chemicals which increased 17.5% and manufactured nonmetallic minerals which rose 10.6%.

The geographical distribution pattern, based on value, for most selected mineral exports was similar in 1976 to that in 1975. There were, however, some important exceptions. In the case of nonferrous metal scrap, the share of exports to noncentrally planned Europe, declined from 49% in 1975 to 37% in 1976 while that of noncentrally planned Asia rose from 34% to 47%. The distribution of exports of uranium and thorium ores and concentrates shifted slightly away from noncentrally planned Europe, which dropped from 100% to 86%, and to North America, which rose from zero to 14%. The share of iron and steel hoop and strip exports to North America decreased from 43% to 32% and those to noncentrally planned Europe rose from 29% to 48%. The distribution of silver, platinum, and platinum-group metals exports shifted away from noncentrally planned Europe which declined from 63% to 29% and to noncentrally planned Asia which increased from 15% to 51%. The change in the pattern of lead and lead alloys exports was a shift away from noncentrally planned Europe, which decreased from 65% to 19%, and to both North America, which rose from 13% to 48%, and noncentrally planned Asia, which increased from 7% to 17%. The distribution of exports of uranium and thorium and their alloys shifted away from noncentrally planned Asia, which declined from 34% to 4%, and to North America, which rose from 26% to 59%.

Imports.—The total value of selected minerals and mineral products imported in

1976 increased 24.5%. Imports increased in all sectors: Crude nonmetallic minerals rose 5.4%; crude and scrap metals increased 14.6%; and mineral energy resources and related products increased 28.5%. Imports of chemicals increased 53.9% and within this category radioactive and associated materials except uranium and thorium increased 237.2%. Both manufactured nonmetallic minerals and manufactured metals increased 10%.

The geographical distribution pattern, based on value, for almost all selected mineral imports in 1976 was similar to that in 1975, though there were several significant exceptions. The share of imports of mica, including scrap, supplied by North America decreased from 16% to zero and that supplied by noncentrally planned Asia decreased from 72% to 51%, while that from South America rose from 6% to 31%. The distribution of crude barite imports from North America and South America declined from 27% to 15% and from 33% to 20%, respectively, and that from noncentrally planned Europe increased from 24% to 45%. Imports of columbium ores and concentrates from South America declined from 60% to 39%, from noncentrally planned Asia declined from 22% to 4%, and from North America increased from 1% to 32%. The distribution of lead waste and scrap imports shifted away from North America, which supplied 37% of U.S. imports in 1976 compared with 98% in 1975, and to South America, which supplied 44% in 1976 compared with nothing in 1975.

Consumption.—In 1976 consumption of most major mineral products increased and the few that declined, fell by small amounts with one exception. Most ferrous metals showed significant increases. Iron ore and raw steel consumption each rose 9.9%. Metallurgical-, refractory-, and chemical-grade chromite ores gained 12.2%, 10.4%, and 24.7%, respectively, the last gain being the largest increase of any ferrous metal. Tungsten consumption increased 15%, molybdenum decreased 2.5%, and manganese declined 12%. Consumption of all major nonferrous metals increased. Apparent consumption of aluminum rose 31.1%, refined copper consumption increased 29.8%, and primary mercury showed the largest increase of all major mineral products at 40.5%. All classes of zinc rose more than 25%, followed by platinum-group metals at 22.5%, ilmenite and titanium slag at 19.7%, and primary antimony at 18.1%. Primary and secondary lead consumption rose 14.9%; estimated purchases of uranium by private industry, 12%; and silver for industry and the arts, 8.2%. Consumption of all nonmetallic minerals increased except for crushed stone which declined a negligible amount. Within the nonmetallics sector apparent consumption of potash showed the largest increase at 20.3%, followed by asbestos at 19.4%. Sand and gravel consumption rose 12.2%, salt increased 10.8%, and that of clays gained 7.7%. Lime and cement each increased 5.7%, all forms of sulfur rose 1.6%, and phosphate rock increased a negligible amount.

Total energy resource inputs in terms of British thermal units (Btu) rose 4.9% in 1976. Consumption of bituminous coal and petroleum including natural gas liquids increased significantly while natural gas increased slightly and anthracite remained unchanged. Total net electricity generation increased and within the utilities sector, nuclear showed the largest increase followed by conventional fuel-burning plants; hydropower declined. Generation of industrial electricity increased slightly.

ENERGY

Energy use rose in the United States in 1976, reversing a 2-year decline. The 4.9% increase compared with 1975 was largely attributable to a higher level of economic activity and colder weather. Net imports of all fuels rose 24.3% compared with 1975; net imports of crude petroleum and petroleum products increased 21.4% over 1975, accounting for 40.6% of the estimated 1976 petroleum demand. Consumption on a Btu basis rose in 1976 for all fossil fuels, but declined for hydropower because of the Western drought. Per capita energy use increased 4.1% compared with 1975. The ratio of energy consumption to GNP in 1976 continued to follow the decline that began in 1971. This decreasing ratio indicates that the U.S. economy is using energy in a more efficient way to create GNP.

Production.—Total energy equivalent in Btu's obtained from mineral energy resources produced and from hydroelectric and nuclear power continued to decline slightly in 1976. The total was nearly 60,000 trillion Btu. Energy obtained from bituminous coal and nuclear power increased while that obtained from petroleum, hydroelectric power, and natural gas decreased. Natural gas continued to be our largest source of energy, accounting for 36% of the total.

Consumption.—U.S. energy consumption in 1976 increased 5% to 74,000 trillion Btu, nearly reaching the 1973 level. This increase came mainly from the use of bituminous coal and petroleum products. Natural gas, the other large source of energy consumption, increased only slightly.

The consumption of energy resources in 1976 by sector was 29% by the industrial sector, 26% by transportation, 25% by household and commercial, and 19% by electric utilities. Petroleum, the major source (47%) of all energy, accounted for nearly all of the energy in the transportation sector, 29% in industrial, 34% in household and commercial, and 24% in electric utilities.

Coal.—The domestic supply of bituminous coal and lignite in 1976 increased 7.4% to 597 million tons; that of anthracite decreased 1.3% to 5.0 million tons. Exports of bituminous coal declined 9.5% to 59 million tons and those of anthracite rose 8.5%. Imports of bituminous coal increased 28% but remained small when compared to exports. Electric utilities were responsible for three-fourths of bituminous coal consumption, and industrial uses accounted for most of the remainder. The household and commercial sector accounted for 40% of anthracite consumption; industrial uses accounted for 33%; and electric utilities, 27%.

Natural gas.—The domestic supply of natural gas increased 2% in 1976 to 19,800 trillion cubic feet or 20,200 trillion Btu. Production continued to decline somewhat as did exports. Imports accounted for 5% of total supply and increased very slightly. Demand for natural gas increased in the industrial sector to 43% of total demand and the household and commercial sector increased to 38% of demand.

Petroleum.—The domestic crude oil supply increased 8.1% to 4,910 million barrels in 1976. Domestic production continued to fall, declining 2.6% to 2,976 million barrels. Imports, which rose 29.2% to a record 1,935 million barrels, were responsible for the increased supply. Exports and stocks increased, but both remained negligible. The domestic supply of refined petroleum products rose 7.2% to 6,384 million barrels. The demand for petroleum increased for all consuming sectors except the miscellaneous category. Transportation continued to be the largest consuming sector, accounting for 61.2% of all petroleum consumed.

Nuclear Energy.—Nuclear energy consumption in 1976 rose 10.8% compared with that in 1975. On a Btu basis it accounted for 2.8% of total energy consumption in 1976, up from 2.6% in 1975.

Hydropower.—In 1976 electricity from hydropower declined for the second year in a row, decreasing 4.8% compared with that in 1975. Hydropower was responsible for 4.1% of total energy consumption in 1976, falling from 4.6% in 1975.

Other Energy.—Work continued in 1976 on development of alternate sources of energy such as geothermal, oil shale, solar, nuclear fusion, wind, tidal, and biological

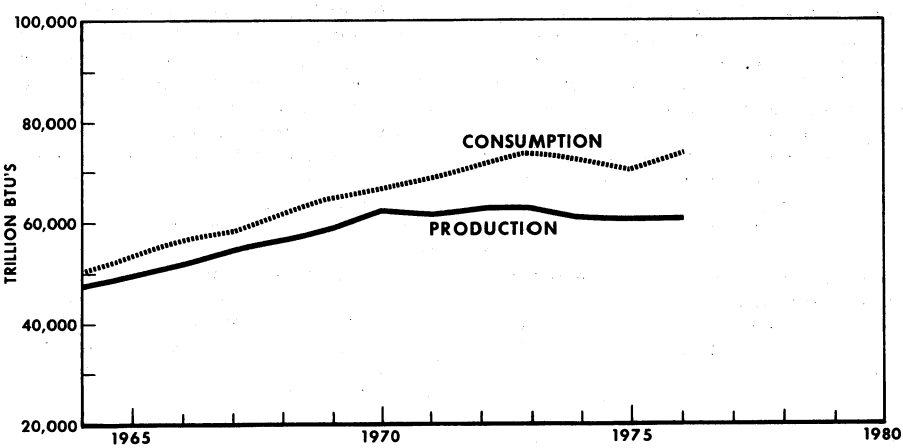

Figure 4.—Production and calculated gross consumption of mineral energy resources and electricity from hydropower and nuclear power.

(from organic wastes). Of these energy sources, geothermal remained the only one that has reached commercial development to any significant extent. Solar energy systems were approaching the commercial stage at some geographic locations. Oil shale development advanced in an effort to overcome problems of high costs and environmental concerns. Several projects were underway to produce energy from waste. Among the technologies being advanced are the production of methane from sewage sludge and the organic portion of urban refuse, the use of combustible portions of urban refuse (such as paper, plastics, wood, and rubber) as fuel for powerplants, and the production of oil from wood waste. Research continued on wind power and energy from fusion, the latter being theoretical at the present time, but offering great promise in the long term.

EMPLOYMENT AND PRODUCTIVITY

Employment.—Employment in selected mineral industries increased for all mining industries, except copper and nonmetal mining and quarrying, and half the selected manufacturing industries in 1976. Total mining employment increased 5.1%, and within this category metal mining employment rose less than 1%, nonmetal mining and quarrying remained unchanged, and fuels extraction increased 6.9%. Within the metal mining group, iron ore employment rose 2.4% and copper ores declined 4.3%. In the fuels group, crude petroleum and natural gas fields employment increased 3.4%, bituminous coal increased 6.2%, and oil and gas field services rose 10.8%.

Total selected manufacturing employment declined less than 1% in 1976, and within this category nonfuel mineral manufacturing remained virtually unchanged and fuel manufacturing increased 2.7%. Within the nonfuel mineral manufacturing group, employment declined less than 1% for fertilizers, 2.3% for hydraulic cement, and less than 0.5% for blast furnaces, steelworks, and rolling mills; nonferrous smelting and refining employment increased 2.6%. Within the fuel manufacturing group, petroleum refining rose 1.9%, and other petroleum and coal products rose 6%.

Hours and Earnings.—Average hourly earnings in the extractive industries during 1976 increased 10.5% to $5.99 for nonfuels, and 8.5% to $6.66 for fuels. Also, hours worked rose 1.2% in both the nonfuels and fuels industries resulting in increases in weekly earnings of 12.1% and 9.8%, respectively. Within the nonfuels industry average hourly earnings increased 9.8% for metal mining and 10.9% for nonmetallic mining and quarrying, though the latter continued to pay the lowest hourly wages in the extractive sector. Hours worked rose 1.7% for the former, and about 1% for the latter which also had the longest workweek of any extractive sector. Weekly earnings rose about 12% for both industries. Within the metal mining sector, both hourly and weekly earnings for the iron ore industry increased almost 12%. Copper ores average hourly earnings rose 10.6% and average weekly hours rose 2.3%, resulting in an increase in average weekly earnings of 13.1%.

The bituminous coal industry continued to pay the highest hourly wages and have the shortest workweek of all extractive industries with $7.91 and 39.5 hours, respectively, representing increases of 9.4% for wages and almost 1% for hours. Crude petroleum and natural gas average hourly earnings increased 8.9% and average weekly hours rose 1.5%, resulting in an increase in average weekly earnings of 9.6%.

The average hourly earnings for total selected manufacturing rose 7.5% to $7.21; average weekly hours decreased 1.5%; and resultant weekly earnings were 9% higher in 1976. The blast furnaces, steel and rolling mills industry continued to pay the highest hourly wages and have the shortest workweek of all manufacturing industries considered, with $7.86 and 39.8 hours, respectively, representing increases of 10.5% for wages and 1.5% for hours. The opposite was true of the fertilizer industry (complete and mixing) which paid the lowest hourly wages at $4.88 and had the longest workweek at 43.1 hours in the manufacturing sector, representing increases of 10% and 1%, respectively. Hydraulic cement experienced the largest percentage increase in average hourly earnings of any industry at 14.7% and, coupled with an increase in weekly hours of under 1%, also showed the largest weekly earnings increase of 15.5%. Average hourly earnings for nonferrous smelting and refining rose 10.7%, average weekly hours rose 2%, and weekly earnings increased 12.9%. For petroleum refining and related products, average hourly earnings rose 11.2%, hours worked increased 1.4%, and resultant weekly earnings rose 12.8%.

Wages and Salaries.—In 1976, total wages and salaries for all industries rose substantially to $891.8 billion, an increase of 10.7%. Total wages and salaries in both the mining and manufacturing sectors rose nearly 13% to $12.2 billion and $238.2 billion, respectively. Average yearly earnings per full-time employee in all industries rose 7.2% to $11,623. Mining sector employees earned an average of $16,089 in 1976, a gain of 8.9% compared with 1975. Manufacturing sector employee earnings rose 8.3% to $12,888.

Labor Turnover Rates.— The accession rate (hires and rehires) for most industries generally increased after a 2-year overall decline. In the manufacturing sector the accession rate increased 5% over that of 1975. The greatest overall increase occurred in the nonfuel mineral industry sector; this was attributed to the copper ore sector with a 68% increase and the nonferrous smelting and refining sector with a 44% increase. Within the selected fuel industries, all sectors increased with the exception of the coal industry which decreased 13% overall. The separation rate declined for all of the selected industries with the exception of the fuel-related industries. In the manufacturing and copper ore sectors, the decrease was 9%; metal mining decreased 6% while both blast furnaces, steel and rolling mills, and the nonferrous smelting and refining sectors each decreased 26%. Iron ore changed the least by decreasing 3% and the cement, hydraulic sector separation rate decreased 31%. Petroleum refining and related industries increased 5%, petroleum refining alone increased 16%, and the separation rate for the coal mining sector increased 28%, the greatest increase for the fuel-related sectors. The layoff rate decreased for all nonfuel mineral sectors while the rate for fuel-related sectors increased. The greatest layoff decline was for nonferrous smelting and refining at 70% and cement, hydraulic was next with a decrease of 45%. The manufacturing sectors decreased 38% and the blast furnaces, steel and rolling mills followed, decreasing 36%. Metal mining decreased 20%, iron ore decreased 23% and copper ore at 15% decreased the least within the nonfuels sector. Petroleum refining and related industries remained constant relative to 1975 while the petroleum refining layoff rate increased by two-thirds; coal mining increased by one-half. The last two rates reflect low base figures.

Productivity.—Indexes of labor productivity for selected minerals in 1975 (latest data available) were mixed. All indexes for copper increased while those for iron and bituminous coal and lignite declined. Indexes of copper ore output per employee, production worker, and production worker man-hour rose about 2%, 5%, and 10%, respectively. For recoverable copper metal, the corresponding indexes increased 0.4%, 3.4%, and 8.2%, respectively. The indexes of iron ore output per employee and per production worker each decreased about 3%, and the per production worker man-hour index dropped 1.3%. Indexes of usable iron ore mined per employee, production worker, and production worker man-hour declined 7.5%, 6.9%, and 5.5%, respectively. For bituminous coal and lignite, the indexes of output per employee and per production worker each declined about 8% and the per production worker man-hour index declined 10.2%. Indexes for refined petroleum were mixed, with output per employee and per production worker each declining 1% and the per production worker man-hour index increasing 1%.

PRICES AND COSTS

Index of Average Unit Mine Value.—The index of average unit mine value (1967=100) is designed to reflect unit values of mine production. It showed unit mine values for all but two mineral categories increasing in 1976. The overall index of average unit mine value rose 10.4% to 279.4 index points. The total metals index increased 9%, the ferrous metal index increased 13.7%, and the nonferrous metal index rose 3.9%. Within the nonferrous metal category, the base metal index increased 5.5%, the monetary metal index showed a substantial decline of 14.5%, and the other nonferrous metals index increased by the largest percentage of any mineral category at 16%. The total nonmetals index rose 5.5%, with the construction index increasing 8.4%, the chemical index decreasing 3.5%, and the other nonmetals index rising 11.9%. The fuels index increased 11.5%, and within this category the coal index rose 4.2% and the crude oil and natural gas index increased 13.3%.

Index of Implicit Unit Value.—The index of implicit unit value (1967=100) is designed to reflect unit values of the minerals included in the index of physical volume of mineral production. For 1976 it shows the same pattern of price changes as the index of average unit mine value discussed above. The implicit unit value indexes increased for all but two mineral sectors. The overall index of implicit unit value increased slightly over 10% to 278.2 index points. The index for all metals rose 8.2%, the ferrous metal index grew 13.7%, and the nonferrous metal index increased 5.2%. Within the nonferrous metal category, the base metal index rose 6%, the monetary metal index declined 12.4%, and the other nonferrous metals index increased the most of all mineral sectors at 14.5%. The total nonmetal index increased 5.2%, with the construction index advancing 8.5%, the chemical index falling 4%, and the other nonmetals index increasing 12.5%. The fuels index rose 12.3%, and within this category the coal index increased 4.2% and the crude oil and natural gas index increased slightly over 14%.

Prices.—The wholesale price indexes for selected metals, minerals, and fuels increased in general for 1976. The index for all commodities increased 4.6% to 183.0 index points, while all commodities other than farm and food increased 6.4% to 182.4 index points. Metals and metal products increased 5.5% to 195.9 index points; selected commodities within this grouping that reflected the extremes of the reported price index changes were as follows: Nonferrous scrap increased 21.1%, foundry and forge shop products increased 12.5%, iron ore increased 10.8%, and aluminum, primary, buyers increased 10.6%. Most other commodities that are listed within this grouping increased at a rate above the 5.5% group average, with the exception of zinc, slab, prime western which had decreased 3.4%.

Nonmetallic mineral products increased 7.0% to 186.3 index points. The greatest increases occurred for building lime, which increased 10.3%, and concrete ingredients and insulation materials, both increased 8.4%. The greatest decreases were as follows: Phosphates down 20.5%, fertilizer materials down 17.7%, and nitrogenates down 15.4%.

Fuels and related products and power increased 8.4% to 265.6 index points. Within this group of commodities, gas fuels increased the most, at 32.3%, followed by petroleum products, refined and electric power with increases of 7.4% and 7.3%, respectively; coal declined 4.4%.

Prices of most mineral energy commodities increased in 1976. The average price of bituminous coal at merchant coke ovens rose 4.3% to $54.90 per short ton. Average sales realization prices for anthracite ranged between $29.11 and $47.13 per ton, with a decrease of less than 1% for one size of anthracite and an increase of 5.4% for another size. All petroleum and petroleum products increased in price with the exceptions of Bunker C residual fuel oil at all gulf ports and No. 6 residual fuel, maximum 1% sulfur, at Philadelphia, which declined almost 3% to $9.03 per barrel and 2% to $12.05 per barrel, respectively. The average price of No. 6 residual fuel, maximum 0.3% sulfur, at Philadelphia, rose almost 1% to $13.28 per barrel. The average price of crude petroleum at the well increased 7.7%, and the average dealers' price of gasoline rose 9%. Prices of No. 2 distillate fuel oil rose 8% at Philadelphia and 5% at all gulf ports. The average value of natural gas at the well rose 30.3% to 58 cents per thousand cubic feet and it was unavailable at the point of consumption.

In the year 1975 (latest data available), the average cost of electricity increased at the same rate as in the past few years. Different from previous years, New England and Middle Atlantic regions had the highest costs, reflective of the high cost of petroleum on the spot market. The Tennessee Valley Authority charged rates in the East South-Central States that permitted this region to continue to have the lowest average cost of electricity for the United States. The average cost of electricity in the residential market increased 0.4 cent to 3.2 cents per kilowatt-hour. All other geographic regions had increases averaging 0.4 cent per kilowatt-hour. In the commercial and industrial sectors the average increase in 1975 was 0.4 cent per kilowatt-hour. The only decline in rates occurred in Alaska and Hawaii, where the residential rate decreased 0.1 cent per kilowatt-hour.

Principal Metal Mining Expenses.—The index of principal metal mining expenses (1967=100), following the price trend for the economy as a whole, rose 5.3% to 199 index points in 1976. The fuel component increased 8.5%, the largest percentage increase of any component, reaching 266 index points, and the electrical energy component was next, rising 7.8% to 208 index points. The supplies component increased 6.2% to 188 index points and labor, with a gain of 4.2% to 198 index points, was the only component rising less than the overall price index.

Costs.—In 1976, indexes of relative costs and productivity (1967=100) generally increased with a few exceptions. For iron ore, all three indexes increased—the index of labor costs per unit of output and the index of value of product per production-worker-period both increased moderately as the index of labor costs per dollar of product rose slightly. The copper indexes showed mixed changes—the index of labor costs per unit of output declined slightly, the index of value of product per production-worker-period increased by more than one-fourth, and the index of labor costs per dollar of product declined moderately. For bituminous coal, the index of labor costs per unit of output rose moderately, the index of value of product per production-worker-period declined slightly, and the index of labor costs per dollar of product rose moderately. In 1974 (latest data available) the petroleum indexes of labor costs per unit of output and the value of product per production-worker-period both increased and the index of labor costs per dollar of product declined as reported in 1973.

Price indexes for mining construction and material handling machinery and equipment (1967=100) increased only moderately in 1976 compared with large increases in 1975. The index for portable air compressors showed the smallest increase at 2%, followed by mixers, pavers, spreaders, etc., at 5% and construction machinery and equipment at 7%. The indexes for specialized construction machinery, scrapers and graders, and tractors other than farm, all increased about 8%. The index for power cranes, excavators, and equipment rose 9%, the oilfield machinery and tools index rose 11%, and the largest price index increase was again for mining machinery and equipment which rose 15%.

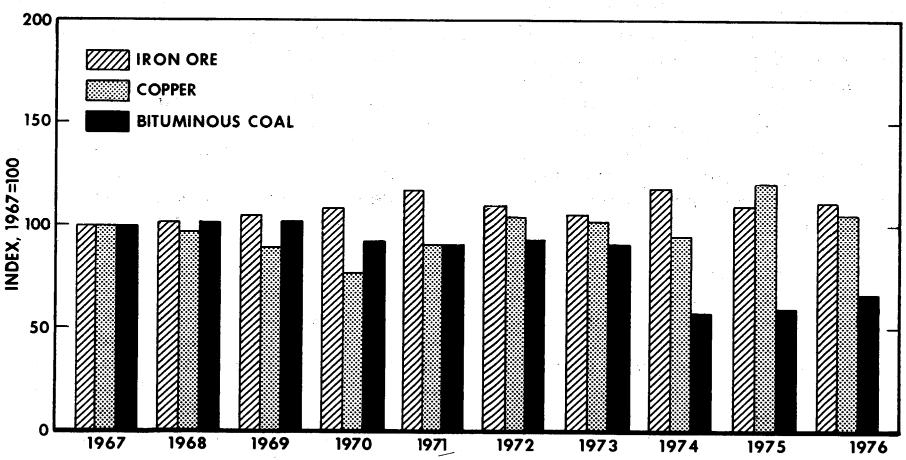

Figure 5.—Index of labor costs per dollar of product.

INCOME AND INVESTMENT

National Income Generated.—National income originating in all industries in 1976 increased 12.2% to $1,399 billion. Income in the mining sector rose to $19.4 billion, an increase of 7.8%. Oil and gas extraction accounted for the largest share within the mining sector at $8.8 billion and also showed the greatest percentage increase in mining at 12.9%. Coal mining contributed the next largest share, rising 3.4% to $6.6 billion. Nonmetallic minerals, excluding fuels, increased 3.1% to $2.3 billion and metal mining rose 7.2% to $1.8 billion. Manufacturing increased 17.2% in 1976 to $365.0

billion. Within this category, petroleum and coal products showed the largest percentage increase, up 25% to $15.5 billion. Stone, clay, and glass products had the second largest increase at 19.5%, rising to $11.8 billion. The primary metal industries generated $26.6 billion in income, a gain of 8.4% and chemicals and allied products accounted for $27.1 billion, an increase of 13.6%.

Profits and Dividends.—The average annual profit rate on shareholders' equity in all manufacturing industries rose by more than two percentage points in 1976 to 14%. All but two of the selected mineral manufacturing industries showed increasing profit rates. The profit rate for primary metals declined a negligible amount to 8.3% and that for iron and steel decreased by almost two percentage points to 9%. Nonferrous metals increased more than one-third to a profit rate of 6.8%; stone, clay, and glass products rose almost four percentage points to 11.9%; chemicals and allied products increased a negligible amount to 15.5%; and petroleum and coal products rose almost two percentage points to 14.4%.

Total dividends for all manufacturing increased 13.8% to $22,716 million in 1976. Dividends rose for all but one of the selected mineral manufacturing industries. For primary metals, they increased 1% to $1,200 million, which was a result of iron and steel increasing 3.6% to $773 million and nonferrous metals declining 3.8% to $425 million. Dividends for stone, clay, and glass products increased 6.5% to $440 million; for chemicals and allied products the increase was 13% to $3,128 million; and for petroleum and coal products the increase was 4% to $4,414 million.

The total number of industrial and commercial failures and their current liabilities declined rather substantially in 1976. The number of failures decreased 15.8% to 9,628 and their liabilities dropped to slightly over $3 billion, a decline of more than 31%. Mining failures rose to 37 in 1976, 11 more than in 1975. The current liabilities of mining firms that failed were almost $106 million, more than 10 times those of 1975. The manufacturing sector showed a decline of 18.3% in the number of failures, but their liabilities increased by a negligible amount.

New Plant and Equipment.—Expenditures for new plant and equipment increased for mining (including fuels) and for all but one of the selected mineral manufacturing industries in 1976. Expenditures by mining industry companies rose 5.5% to $4.0 billion; those by all manufacturing increased 9.4% to $52.48 billion. Primary nonferrous metals industry expenditures showed the only decline of the selected mineral manufacturing industries, decreasing by 5.3% to $2.16 billion. Expenditures by the primary iron and steel industry increased by 2.7% to $3.81 billion and those by chemicals and allied products increased by 6.9% to $6.68 billion. Petroleum industry expenditures increased 10.6% to $11.62 billion, and stone, clay, and glass products industry expenditures showed the largest percentage increase, a rise of 21.1% to $1.72 billion.

Plant and equipment expenditures of foreign affiliates of U.S. mining companies in mining and smelting declined by 21.9% to $916 million in 1976. Canada showed a decrease of 8.2%, Latin America showed a decrease of 39.4%, and the all other areas category fell 30%. Expenditures in petroleum rose almost 3% to $9,757 million. Canada showed an increase of 5.2%, expenditures for Latin America declined 15.8%, those for Europe increased 9.8%, and all other areas remained at virtually the same level as in 1975. Plant and equipment expenditures in manufacturing rose 2%, with Latin America increasing 19.1% and the all other areas category falling 11.8%.

Issues of Mining Securities.—Estimated gross proceeds of new securities offered by extractive industries totaled $1.77 billion in 1976, an increase of 8.6% from that of 1975. As a departure from previous years, bonds accounted for 57.8% of the proceeds in 1976, while common stock's share was only 34.3% and preferred stock was responsible for 7.9% of the proceeds.

Foreign Investment.—Direct private investment by U.S. companies abroad increased 12% to $133.2 billion in 1975 (latest data available). The increase in the petroleum sector was 15.3%. The share of petroleum investments received by developing countries continued to be greater than the share of total investments they received. Developed countries received $20.3 billion of the petroleum industry investment, while developing countries received $11.1 billion. The value of petroleum investment in European affiliates increased 14.3% to $11.4 billion and that in Canadian affiliates increased 8.3% to $6.2 billion. Petroleum investments were up sharply in two developing areas: The Middle East increased 127.7% to $3.7 billion and the Other Asia and Pacific category rose 59.5% to $2.8 billion.

U.S. direct investments in foreign mining increased 7% in 1975 (latest data available) to $6.6 billion. The developed countries received two-thirds of these investments or $4.4 billion. Canada received the largest share, or 69.4% of mining investments in developed countries. Latin American Republics continued to account for almost half of mining investments in developing countries which totaled $2.1 billion.

The value of foreign direct investments in the United States in 1975 (latest data available) was $26.7 billion, an increase of 19.3%. Investments in the petroleum sector increased 37% to $8.2 billion, which was 30.6% of the total foreign direct investments in the United States.

TRANSPORTATION

The total quantity of major minerals and mineral energy products transported by railroad and water continued to decrease in 1975 (latest data available), declining by 95.4 million short tons to 1,642 million short tons. Total mineral products accounted for 62% of all products carried by rail and 82% of all commodities transported by water. The former represented a small increase over that of 1974. Almost 65% of minerals, excluding fuels, were transported by rail. Slightly over 55% of fuels and related energy products were transported by water.

In the minerals, excluding fuels, category the quantity of commodities transported by rail decreased 15.9% to 406.6 million short tons. Of this total 61.9% consisted of five commodities: Iron ores and concentrates, phosphate rock, steelworks and rolling mill products, sand and gravel, and crushed stone. All commodities decreased in 1975 except for nonferrous metal scrap, which increased 365%, and phosphate rock, which rose less than 1%.

Water transportation of minerals, excluding fuels, declined almost 13% to 220.4 million short tons. Three commodities—iron ores and concentrates, sand and gravel, and limestone flux— accounted for 75.5% of this tonnage. All commodities decreased with the exceptions of phosphate rock, which increased 10%, and other ores, which increased 6%.

In the fuels and related energy products category, the quantity of commodities carried by rail rose 2.1% to 456.2 million short tons in 1975. Bituminous coal and lignite continued to be responsible for the major share, accounting for 89.3% of this tonnage. All fuel products declined in 1975 except for coal, which increased 4.3%, and crude petroleum and natural gas, which rose 5.6%.

Fuels and related products transported by water increased less than 1% to 559.2 million short tons. Coal continued to account for the largest share of fuels shipped by water at 27.3%. Others responsible for significant shares included residual fuel oil at 20%, gasoline, jet fuel, kerosine at 19%, distillate fuel at 16%, and crude petroleum and natural gas at 14%. The largest percentage increase was for liquefied petroleum gas and coal gas which rose 21.4%.

A total of 987,700 miles (preliminary) of gas pipelines existed in 1976. This represents an increase of less than 1% from the 980,000 miles of pipelines that existed in 1975. Total petroleum pipeline mileage in 1974 (latest data available) as previously reported was 222,000 miles. It was distributed among the following components: Crude gathering systems in field operations with a 31% share, large-size crude trunklines accounting for 34%, and petroleum product pipelines that extend from refineries to extraction terminals with 35%.

RESEARCH ACTIVITIES

U.S. total research and development expenditures in 1975 (latest data available) were $23.5 billion, an increase of more than 5% compared with that of 1974. The shares spent by the private sector and the Federal Government were 62.8% and 37.2%, respectively, the same percentages as in 1974. Research and development expenditures in the petroleum refining and extractive industries increased 17%, reaching $700 million in 1975. Almost 96% of these expenditures were financed by private industry, and Federal Government funds supplied the remaining 4%. Research expenditures for chemicals and allied products increased over 12% to $2,650 million. Private industry financed 91% of this total.

Bureau of Mines funding obligations for mining and mineral research and development were $131.3 million in fiscal year

1976, an increase of 29% compared with 1975. Funds for applied research increased more than 42% to $72.5 million. Basic research funds continued to drop, declining 58.7% to $0.8 million. Funds for development rose 19% to $58 million. Funding obligations for fiscal year 1977 were estimated at $153.7 million, 17% higher than for 1976. Fiscal year 1977 funds were estimated to increase 8.8% to $78.9 million for applied research, to remain the same for basic research, and to increase 12.7% to $65.4 million for development.

Bureau of Mines funding obligations for total research rose 38.5% to $73.3 million for fiscal year 1976. Funds for engineering sciences increased 41.5% to $67.5 million; physical sciences funds declined 5.6% to $1.8 million; mathematical sciences rose 24.5% to $1.6 million; and environmental sciences increased 18% to $2.4 million. Obligations for total research during fiscal year 1977 were estimated to increase 8.7% to $79.7 million. Funds for engineering sciences were estimated to increase 9.3%; for physical sciences they were estimated to rise 5.6%; and for both mathematical and environmental sciences they were estimated to remain the same. Highlights of Bureau research programs, including work in progress, follow.

Mining.—The Bureau continued to make field studies with shallow seismic reflection methods for mapping coal seams and underground geologic features in coal mines in 1976. Only recently has this technique been applied to shallow investigations. The application is similar in effect to the deeper methods already utilized; however, shallow reflection methods require modified procedures. Some of these are to minimize surface noise, select optimum detector spacing, generate high-frequency source signals, and use improved data collection and data processing technology. The seismic method was proving useful for locating geologic features at moderate cost and with better definition than available with drilling programs alone.

The Bureau developed a first-generation roof bolter inserter (R.B.I.) and flex drill system. The R.B.I. is designed to bend and insert longer than seam height bolts without the need to manually bend and straighten the bolts. It removes the miner from the hazardous bolting area to improve safety. This is done by moving the operator's controls to the back of the bolter and moving the operator away from the bolter altogether and controlling its operations remotely. Completion of the R.B.I. has led to the next step of drilling longer than seam height. Five flexible drill contracts investigated different methods of achieving the goal of longer than seam height drilling.

The Bureau of Mines embarked on a contract research effort to develop a fast, reliable, accurate, and effective reconnaissance system to gather and quantify data on stability of mine waste embankments. After investigating a number of systems involving conventional surveying, telemetry, remote sensing, and innovative techniques, the airborne photogrammetry system was selected as the one that best combines accuracy, rapidity, and reliability with reasonable cost.

Photogrammetry is both fast and accurate; embankments can be photographed in a fraction of the time required for onsite visual inspection and surveying. Additional benefits are that site mapping is facilitated, embankment volume can be measured, and a permanent, reliable record of the life of the embankment results.

The deep, steeply dipping narrow veins of the Coeur d'Alene mining district are mined by overhand horizontal cut-and-fill methods. High ground stresses and hard brittle rock can result in conditions conducive to rockbursts. Experience has shown that many of the damaging rockbursts occur during development of the stope first level and later during mining of the remaining stope sill pillar. Finite element studies showed that if the rock in this area of the mine could be made less brittle during development mining, the potential for rockbursts would be greatly reduced. A cooperative research program was planned between the Bureau of Mines and a mining company to test this theory.

A Bureau program was generated for the development of potential recommended guidelines for underground mining in close proximity to bodies of water. The objective was subject to the constraint of maximum efficient utilization of underground coal resources consistent with minimizing inundation hazards. Several consulting firms were contracted to gather and provide background data from worldwide sources on the application and the case histories of previous inundations to develop recommended guidelines for underground coal mining near bodies of water.

These recommended guidelines cover total extraction by longwall or pillar robbing, partial extraction by room-and-pillar, partial extraction by panel mining, and a combination of these methods.

The Bureau of Mines continued to conduct projects involving the development and in-mine testing of rugged, reasonably priced, mine shaft fire and smoke protection systems. A second-generation system, developed and installed in a mine near Bishop, Calif., was tested in 1976. The system's hardware consists of smoke, CO, and heat sensors, remotely controlled smoke doors, remotely controlled sprinkler systems in the shaft/shaft station area, underground control units, and a master control unit at the surface. After 8 months of in-mine evaluation, the second-generation prototype system was subjected to fire testing. Test fires were lit at two levels of the mine. Each test fire was automatically sensed by the systems; the remotely controlled smoke doors were activated and the remotely controlled sprinklers successfully extinguished the fires via commands from the surface.

Bureau research is concerned with several aspects of circuit protection for mine power systems, ranging from circuit breaker reliability to development of more sensitive and trouble-free devices for detection of ground faults. In one study, existing circuit breakers are being replaced by matching units which are equipped with monitoring devices to provide data on occurrences of circuit current surges and the related circuit interruption performance of the breaker. The old breakers are examined for wear and failure characteristics, as will be the new units when finally removed. Aside from reliability and maintenance scheduling information, the investigation will probably also result in suggestions for circuit breaker improvement and for proper application of the devices.

A "synthetic fault" test apparatus had been developed for in-mine testing and verification of operational readiness of ac circuit breakers.

A second circuit breaker tester was being developed; this one for calibrating dc trolley system circuit breakers.

An experimental model of a dc circuit breaker which almost instantaneously interrupts large fault currents with no arcing across the contacts had been fabricated and was undergoing tests.

The detection of incendive ground fault currents on the order of 10 amperes in trolley line systems, where normal currents may be in excess of 3,500 amperes, is accomplished by means of a "discriminating circuit breaker system." The method by which the system distinguishes a dangerous ground fault from a low resistance normal load involves injection of a 3,000-hertz audio signal into the system and the sensing of current flow at that frequency. All legitimate loads such as pumps, jeeps, and locomotives operating on the line must be equipped with filters to block the flow of 3,000-hertz current, whereas the current will flow freely through a genuine ground fault and cause a relay to trip the circuit breaker. In the present experimental installations, all of the mine vehicles are not equipped with blocking filters; hence, the system cannot be connected so as to actually interrupt the trolley line current; however, 3 years of observation have proven that a fully installed system would be essentially free from nuisance interruptions. Further in-mine evaluation is underway.

The Bureau of Mines in its concern for mine safety has responded by performing research in all areas related to improving the safety of coal mines during the mining operation. Of particular concern are programs to improve the interface of the machine operator and the machine.

Several programs were initiated to achieve this goal; these programs examined innovative machine designs and modification of existing equipment. The innovative machine design program involved complete redesign of equipment, employing human factors engineering in the new designs. The program for modification of existing equipment was broken down into several projects. These projects have been directed toward standardization of controls, panic bar installations, development of low coal canopies, and a survey of available canopies.

Other examples of noncompliance with human engineering principles are the widespread use of identical black, round control knobs (regardless of the function being performed) and frequent inappropriate location, spacing, and labeling of controls. Any or all of these factors may place the operator in a "negative transfer" situation, which means that control manipulations appropriate for one type of machine are different from (or even in the reverse of) the control movements required to produce the same effect of other machine types. The goal of this project was to develop and evaluate criteria for standardized controls for underground electric face equipment.

Several projects were initiated under the protective canopy program to develop protective canopies that were easily retrofitted to existing equipment used in various seam heights. The results of these projects have been combined into one study that applies human engineering principles in conjunction with these past research programs to develop optimized operator compartments. Three projects were initiated under the optimized operator compartment program. These projects were similar with the objective of fabricating operator compartments that were easily retrofittable to existing equipment and included the results of the standardization of controls project, the panic bar project, and the various canopy projects.

One of the optimized operator compartment projects has been completed on an Elkhorn scoop and a pair of National Mine Service shuttle cars. The two shuttle cars were sold to a mining company for use in its mine; the company agreed to accept the cars with optimized operator compartments and evaluate them in normal operation during the months of March and April 1976. The compartment was very well received by the drivers and other mine personnel.

A coal company agreed to cooperate in finding a maintenance shop to modify its Elkhorn Scoop compartment to the optimized operator compartment configuration and to participate in the in-mine evaluation of the scoop. The modifications to the scoop compartment were completed in January 1976. The scoop compartment was then evaluated by the scoop operators, while performing their normal duties, during the months of February and March 1976.

The broad objective of the Bureau's mine machinery equipment training program is to improve the safety and productivity of new operators of underground mine machinery by the systematic and disciplined development of equipment training systems. The present scope, as determined by historic accident and hazard analyses, includes the development, implementation, and validation of miner, roof bolter, and hoist equipment operator training systems.

In providing detailed information concerning equipment operation, a shuttle car training system was developed under contract by Doron Precision Systems. The trainer concepts evolving from the training system analysis have included the development of classroom material, a dynamic concepts trainer, and a reaction trainer. The reaction trainer was designed to teach and provide drill and practice in hazard recognition and avoidance. As such, the reaction trainer is designed to partially simulate the shuttle car and working section with a sufficient degree of fidelity to realistically present many of the hazards a shuttle car operator may encounter. Efforts were underway to adapt this training system to the development of training packages for roof bolter, continuous miner, and hoist equipment operators.

While the machinery trainers address an important area, another technique with broader applicability in terms of general training and testing is the Lincoln Training System (LTS), which is a self-paced, interactive, audiovisual trainer. All information (audio, visual, and control information) is contained on low-cost microfiche. Prototype systems have been evaluated at coal mine training sites with excellent acceptance.

Health-related research is focusing on such problems as respirable coal dust, radioactive gas, noise, toxic mine gases, and on solutions involving both protection of miners and control of the mine environment through engineering advances.

Projects were underway to prevent and control dust generation, improve face ventilation, and develop personal protective devices. Research continued on the radiation hazard which continues to be a major health concern in uranium mines. The major objectives are to improve techniques to inhibit or control radon emanation into the mine air and to develop measurement instrumentation such as a viable personal dosimetry system for measuring miner exposure to specific types of radiation.

Research continued on noise abatement in order to achieve acceptable levels of noise exposure for personnel engaged in coal and noncoal mining activities, both underground and surface. Noise instrumentation was being improved to meet continuing demand for more accurate assessments of noise levels. An industrial hygiene program was aimed at rapidly measuring/monitoring toxic gases such as CO, NO, and NO_2 through the development of low-cost, reliable measuring instrumentation. Thus, the quality of ventilating air in a mine can be quantified and the miners' accumulative exposure can be measured.

A Bureau of Mines research contract developed methods to increase significantly the amount of fresh air that reaches the front of a continuous mining machine. The contract emphasis was on removing methane buildups that occur at the cutter head.

The key to providing more air at the face is to enhance and move forward the "natural" airflow pattern. Devices designed to enhance and move forward this natural pattern always swept away methane better than those that ignored this simple principle.

One way to move forward the natural pattern is with proper placement of a low volume diffuser fan. A twin nozzle diffuser fan placed on the intake side of the machine works best. One disadvantage of this kind of diffuser system was that it required a second, identical system on the other side of the machine to make the air go the other way when the brattice was moved to the other rib.

Another simple and effective air mover is the conventional water spray. It was discovered that if all the water sprays on the machine were realined to take advantage of their air-moving abilities, then the natural airflow pattern was enhanced even more than with a diffuser fan.

While some care in the selection and placement of spray nozzles is necessary, conventional nozzles work as well in this application as specially designed "air-mover" venturi sprays. These "air-mover" sprays move air through a small diameter short tube that surrounds the spray nozzle. However, this Bureau-sponsored research has shown that the key to better face ventilation is recognizing that the space between the machine and the roof or rib is also a "tube," a far larger tube than could ever be tucked away inside the machine. The solution to more air at the face is a more effective use of this tube that has been there all the time.

In an attempt to reduce both the material costs and the man-hours needed to maintain stoppings in working areas of hardrock mines, the Bureau of Mines developed a new type of stopping, called the quick-fix blowout stopping. This is a variation of the parachute stopping developed earlier by the Bureau. Unlike conventional stoppings constructed in working areas, the stopping is not designed to resist blast forces. Rather, it is designed to be easily blown out by blast forces and then to be quickly and easily reinstalled; in contrast, a conventional timber stopping or bulkhead may require an entire shift to replace. Furthermore, restoring conventional wood or brattice stoppings almost always entails the use of new materials, whereas the quick-fix blowout stopping can be used again and again.

A new, self-sealing brattice developed by the Bureau of Mines offers distinct advantages over conventional brattice as to both weight and tightness. Its main feature is that the fabric is sewn into a hemispherical shape rather than a flat sheet-like conventional brattice. The perimeter of the hemisphere is made larger than the airway perimeter, so that the differential air pressure will balloon out the fabric, forcing it against the mine surface and providing an automatic seal that reduces both leakage and the number of attachment points needed. It should be noted that the Bureau of Mines considers this concept still in the developmental stage. Although it has been shown that this type of stopping can be successfully employed underground, it has never been tested in an emergency situation.

The Bureau of Mines developed a mechanically driven sequential sampler that can automatically take air, gas, or liquid samples in underground mines for periods of 1 to 8 days. The new sampler is basically an Archimedes screw—a spiral of plastic tubing wound around a cylinder, which is tilted so that one end of the tube is submerged in a pan of water. The other end of the cylinder is connected to a spring-wound motor that can rotate the cylinder, one revolution per sample, at set intervals ranging from once a minute to once an hour. As the cylinder turns, the low end of the tubing comes out of the water for half a revolution of the cylinder. As the end of the tube submerges again, a plug of air is trapped in the tube between two plugs of water, and successive air samples are automatically spiraled upward in the tubing as the cylinder rotates.

In 1976 the Bureau continued to explore possible ways of reducing the level of airborne respirable coal dust through improvement in coal mining machines, methods, and systems. The objective of a Bureau contract was to design, construct, and test a full-scale continuous coal miner for the purpose of quantifying the relationships between cutterhead's rotational speed and the depth of cut by the bits into the coal face as related to the generation of airborne respirable dust. The results showed that airborne respirable dust was reduced by greater than 60% in the air return when the depth of cut was increased from 1 to 2 inches. Rotational speed had only a slight effect in the return, but at the operator's station, a reduction of 77% could be realized by slowing the head from 51 to 18 revolutions per minute. The contract has been completed and the machine was being demonstrated under a cooperative agreement with a coal company. The purpose of this demonstration is to show that a drum-type continuous coal miner can operate in a much cleaner mode and yet can maintain or increase production.

More than 90% of the coal in underground mines is hauled by various types of shuttle cars from the mining face to the secondary haulage system. Approximately 72% of the cars are electric powered through a trailing cable. All of the remaining cars are powered by lead acid batteries with the exception of a small number that are powered with diesel engines.

Continuous face haulage systems transport 8% of the underground coal and their application is expected to grow. However, shuttle car haulage will continue to be the predominant face haulage method during the foreseeable future. Shuttle cars, in general, have the relative advantages of low capital cost and high reliability. In the case of the electric trailing cable powered shuttle car, it is a simple and easily maintained vehicle. The principal disadvantages of this kind of vehicle are limited coal capacity and various problems related to the trailing cable. Battery-powered vehicles have the flexibility to travel various paths and eliminate the fire hazard and failure problems associated with the trailing cable. The major problems with battery-powered equipment are limited operating time per charging cycle and downtime due to battery replacement. Diesel-powered shuttle cars have the advantages of battery-powered vehicles and, in addition, have a higher operating time and lower operating cost. The critical problems of diesel-powered shuttle cars are the health hazard of the engine exhaust emissions and noise. In 1976, research was being conducted on all of the problems cited above with the objective of reducing or eliminating them.

A contract was awarded to a firm to maximize the coal carrying capacity and to improve or, at a minimum, retain the existing maintainability and reliability standards of shuttle cars without increasing the outside dimensions. An evaluation was made of all currently used shuttle cars and relevant technology to identify those features and components that could be combined to meet contract requirements. The evaluation has been completed and a shuttle car design is nearly completed that will have a capacity more than 25% greater than existing shuttle cars of equivalent overall dimensions.

Under a contract, an iron-nickel high performance battery for coal haulage vehicles and a more efficient battery charging system was being developed. The iron-nickel battery will have sufficient energy to last a full shift and can be charged and ready for use in less than 3 hours.

Also through a contract, the closed Rankine cycle steam engine that was developed for automotive propulsion has been modified for use in underground coal mine vehicles. The steam powerplant potentially offers significant advantages over existing diesel-powered (internal combustion) vehicles. Emission levels for oxides of nitrogen and carbon monoxide from the steam engine system are anticipated to be approximately less than 10% and 40%, respectively, of those obtained from diesel systems presently in use underground.

Significant advances have been made recently in flywheel materials and technology. Shuttle cars appear to be uniquely suited to the application of flywheel technology. The distance of travel is typically short and the cycle frequency is high. Conceptually, the shuttle car flywheel would be rapidly recharged in fresh mine air while the car is being unloaded at the transfer point. A contract has been awarded to assess existing flywheel technology and its practical application to underground coal mine shuttle cars. The evaluation includes flywheel size and material, methods of charging, recovering, and transmitting flywheel energy, and safety, and cost-effectiveness.

Studies, research, and development are currently underway by the National Aeronautics and Space Administration/ Marshall Space Flight Center for the

Bureau of Mines to develop the coal interface detectors and associated control systems required for the automation of a longwall shearing machine. The specific goal is to define, test, and recommend practical low-cost guidance and control systems and detectors required for the development of an automated bidirectional double-drum arranging shearer/loader.

To date, the following four sensor types have survived the feasibility tests and are being developed further by laboratory and field testing: (1) Nucleonic, which employs back-scattering gamma rays to measure the thickness of coal left on the roof or floor after cutting; (2) radar, which employs an FM or CW single-antenna radar to measure depths of coal and/or strata in roof or floor after cutting (discrimination depends on differences in the dielectric constant of the materials); (3) sensitized pick, which uses a strain-gaged pick block to measure force on cutting bit and discriminates between hard and soft materials; and (4) penetrometer/reflectometer, which is a dual sensor which measures the impact hardness and color of material left exposed on roof or floor. A fifth sensor is being developed for the Bureau that is based on an analysis of the vibration spectrum of the coal-cutting operations.

Concurrent with the detector development work, concepts for shearer guidance and control systems, utilizing one or a suite of detectors, were being evaluated. This evaluation includes mathematical simulation of the control system, identification of hardware design approaches, and the definition of the system requirements.

In addition, studies were being conducted on methods for measuring the alinement of the longwall coal face with respect to established mine reference locations. Measuring instruments that can measure the path of the face conveyor (yaw) have been developed and were undergoing laboratory evaluation. Instruments also have been identified for measuring the shearer tilt (roll attitude).

The choice of detectors will depend ultimately on the physical properties of the roof, coalbed, and floor; the mining strategy (how much coal to leave, how much roof or floor to cut, etc.); and the accuracy of the fully developed sensors.

Because of new impetus on coal to satisfy U.S. energy demands, the Bureau of Mines had a program for improving underground coal production. Part of this effort is the "Automated Continuous Roof Support" subprogram for developing and demonstrating equipment that will increase production and lower coal costs.

An approach to increasing room-and-pillar production is to provide more operating time for high-capacity continuous miners. By installing supports during the mining operation, the separate steps required for mining and supporting can be eliminated. Eliminating separate mining and bolting operations with equipment that can simultaneously mine coal and install roof supports would then enable a miner/bolter to produce 750 tons of coal per shift—a considerable improvement over today's 350-ton rate. The Bureau has contracts to design, fabricate, assemble, and test equipment that combines the bolting and mining functions.

The Bureau of Mines is conducting research to help apply the potential benefits of mining uranium by in situ leaching. In situ leaching presently provides only a small fraction of the Nation's uranium production. There are certain problems to be overcome before in situ leaching will contribute large amounts of uranium. One of these problems is optimizing the type and concentration of chemical lixiviant for the particular ore being leached. A second problem is optimizing the construction of injection wells so as to minimize clogging; in certain types of deposits, organic drilling fluids have caused clogging. A description of the preferred method of making injection wells was being prepared for publication.

The third problem is limiting the lixiviant to the uranium-bearing zones, especially when there are several layers of ore. With conventional methods of placing screens, the barren zones between the uranium-bearing zones are exposed to the lixiviant. An alternative method is to case and grout the well all the way to the bottom of the lowest uranium-bearing zone, then perforate the casing and grout at the desired levels. The Bureau of Mines has developed an excellent technique for making the required perforations by using a high-pressure water jet. The water jet makes smaller, more regular holes than mechanical perforations, and so provides better sand control. The water jet not only can be used to make original perforations, but also can make new holes in a clogged screen. Both applications were tested successfully in

Texas. By such research, the Bureau is attempting to improve the efficiency of in situ uranium leaching so that lower grade and smaller deposits can contribute to the Nation's energy supply.

Explosive fracturing of copper ore bodies in preparation for in situ leaching is a new technology with a high potential for developing low-grade deposits. The Bureau initiated field research to assist mining companies in developing this technology. The Bureau and a mining company conducted a cooperative in situ leaching research program at a mine near Kingman, Ariz. The objective was to develop in situ leaching methods for 200,000 tons of ore exposed in the pit bottom and also 3 million tons of ore under 200 feet of overburden adjacent to the pit. The grade of the ore remaining at the mine had became marginal, and it was no longer economical to continue open pit operations.

In another cooperative research program the Bureau and another mining company began investigating the in situ leaching potential of copper ore along the fringes of an open pit mine near Benson, Ariz. This fringe ore is beyond the projected pit limits and if an in situ leaching system is successful, the life of this mine would be extended and the total copper production would be increased.

The techniques demonstrated by these Government-industry cooperative efforts can be of significant industrial value to any company that is considering the use of in situ leaching.

For over 5 years, the Bureau has sponsored research for the development of a conical reamer for hard rock. This device attacks the hole bottom at an angle, which decreases the force on individual cutter elements to be spaced further apart than is possible with a tricone bit. As a result, this geometry leaves more room for cutter bearings and, consequently, has the potential for longer bit life.

The Bureau, with the cooperation of two firms mining taconite, conducted an extensive field test of the conical reamer blasthole bit on the Minnesota Mesabi Iron Range in 1976. Taconite rock is extremely hard (50,000 to 75,000 pounds per square inch), so these tests enabled the Bureau to evaluate performance under very severe conditions. The tests were considered a technical success, but the economic analysis indicated that for drilling in taconite, the conical reamer bit is more expensive than using a standard bit. The technology has been transferred to industry. A manufacturer recently began marketing the bit and apparently the bit is performing very well in softer formations.

To encourage improved production and work efficiency, the Bureau contracted research for the design, fabrication, and field testing in a vein mine of an improved portable man-rated service hoisting system for transporting men, supplies, and equipment into stopes. The following general requirements were designed into the hoisting system: (1) Capable of operating at a speed of 50 feet per minute under normal 2,000-pound man-rated load; (2) capable of serving a 3,000-foot raise; (3) capable of operating with a 4,000-pound payload of equipment; and (4) capable of being moved and reinstalled quickly and easily in other stopes in the mine. The system was field tested for a 6-week period at a mine in Colorado. Minor modifications and additional in-mine testing and demonstration are planned.

The Bureau of Mines has a contract to develop a remote controlled, mechanized shotcrete placement system for raise drilled shafts. This is to eliminate the major deterrent of the current lining process, which is slow, costly, and dangerous owing to the need for men in the shaft. On a single shift basis, this shotcrete system could conservatively place 30 feet per day figuring 50% of an 8-hour shift to be operating time. By adding two more shifts, this rate could conceivably be increased to 90 feet per day. Based on a conservative analysis, the economics of the system look extremely attractive. Excluding research and development costs, an estimated $9.00 per foot cost saving was realized on the demonstration shaft. Not figured into the cost analysis were such factors as the benefits gained by faster development and the loss of fewer raises due to collapse. The system is undergoing a refinement phase to correct shortcomings noted on mine equipment trials. Subsequently, the system will be demonstrated in a deeper shaft.

The underground auger has the potential advantages of low capital and operating costs, and high tons per manshift output. With a Bureau contract, a project was successfully constructed, demonstrating peak production rates reaching 130 tons per shift or about 25 tons per manshift. An extension to the contract to gather more field data and improve the machine has been granted. Under an in-house project, several high recovery auger mining (Hiream) systems were developed. The first involves drilling square holes with or without temporary support for a potential recovery of 75%. The second system uses a backreaming tool that allows holes to be drilled closer together with or without temporary support for a potential recovery of 72%. During fiscal year 1976, prototype equipment was developed and tested for the square hole drilling system, the circular backreaming system, and the temporary support system, all of which appeared feasible.

Environmental restrictions imposed on contour mining in steep slope areas of Appalachia have prompted the development of new mining techniques, such as the haulback or blockcut method, which permit controlled placement of overburden and eliminate spoiling on the outslopes. The major disadvantage associated with these methods is that production is lowered mainly because of time delays caused by equipment cycling and interference between coal mining and overburden handling equipment causes congestion in the pit area.

The feasibility of portable belt conveyors for handling of overburden either along the lowwall or highwall is being examined under a Bureau contract. These conveyor haulage systems alleviate the pit congestion and production hinderances associated with truck haulage of overburden through the active pit area in haulback and blockcut mining methods.

Two systems each using portable belt conveyors have been developed. In the lowwall concept, the conveyor units are placed along the lowwall side of the pit. A front-end loader places the overburden into a hopper, to screen oversize material, which feeds the belt conveyors. The conveyors transport the material through the pit to the reclamation site. Here a reclamation stacker is used to deposit the overburden for final grading by dozers. In the highwall concept, similar equipment is utilized; however, the conveyor units run along the highwall. A single lift elevator lifts the overburden from the bench to the top of the highwall where it is deposited onto the conveyor units. The conveyors run along the top of the highwall and feed into a highwall reclamation stacker, which deposits the overburden into the pit for final grading.

Evaluations indicate that conveyor haulage of overburden offers numerous advantages over trucks such as potentially higher production rates, additional coal recovery, improved reclamation due to concurrent backfilling, improved spoil placement, and reduced pit congestion. Of the two concepts developed, the lowwall system has the most promise.

Only a small portion of the vast reserves of oil shale can be mined by conventional surface or underground techniques. To recover the remainder of this fuel, a modified in situ technique will be required. Through a contract, the Bureau assessed the technical and economic feasibility of a modified in situ process. In the modified technique, upper and lower development levels are advanced by standard mining methods. Compared to conventional mining methods, the modified in situ method will minimize surface disposal problems, increase resource recovery in thick beds, reduce surface disturbance, and reduce capital plant costs.

Areas of investigation important to the development of a modified in situ operation are the geology and mineralogy of the tract to be mined, rock mechanics for mine design, access mining systems, ventilation requirements, rubblization technique, in situ retorting parameters, safety considerations, and environmental impact.

The feasibility study indicated that modified in situ oil shale mining is a technically feasible, environmentally acceptable, and economically competitive energy alternative. A typical retorting facility producing 50,000 barrels per day from 20-gallon-per-ton shale, utilizing 230-foot-high retorts under 1,000 feet of overburden will produce kerogen for $8.75 per barrel (January 1975 dollars). Various other combinations of parameters yielded costs varying from $7.70 to $15.50 per barrel. Additional economy and resource utilization can be attained by surface retorting of the development material.

The Bureau's environmental efforts are directed to the correction of adverse effects of past mining and mineral processing and to the development of new environmentally acceptable technology for methods of mining and processing in the future.

Most of the current mined-area restoration efforts are in the Appalachian region. Considerable progress has been made in techniques of back-filling mine voids to prevent surface subsidence in urban areas. Surface reclamation projects have demonstrated procedures and costs for converting strip-mined land to such public uses as schools, shopping and residential areas, and recreation.

Results of these research/demonstration projects are applied in the Bureau's administration of the Mining Area Restoration Section of the Appalachian Regional Development Act in which the improvement of environmental quality and protection of public health and safety are major concerns. A demonstration of subsidence control is underway for two residential areas in western Illinois. In the anthracite region of Pennsylvania, the recovery of low-sulfur fuel from mine refuse is receiving major attention. Bureau research into technology for future mining emphasizes surface effects resulting from both underground and surface mining, with special attention to integrated reclamation practices and to prevention of uncontrolled future subsidence.

Reclamation research workshops were held in eight States during the period from December 12, 1975, through June 25, 1976, under a Bureau of Mines contract with the University of Missouri-Rolla. The workshops were designed to help define the Bureau's research and development priorities. At each workshop a summary of current Bureau mine reclamation research was presented, which was followed by identification of problems associated with mine land reclamation in the State where the meeting was being held. Discussions included the seriousness of problems locally and how the Bureau could best undertake research to assist in developing the technology for solving the problems identified. Participants included representatives of State agencies, educational institutions, and companies involved in surface mining.

The Bureau of Mines principal activity in the area of subsidence control has been the development of an improved method for backfilling abandoned mine workings particularly in urban areas. During 1976, surface stabilization was needed in an area in Jessup, Pa., where subsidence had already started. Because caving of the workings would limit the lateral migration of slurry underground, a pumped-slurry demonstration project was tailored to fit the site conditions. Experience was gained in backfilling areas where the uppermost mined coalbed was close to the surface. Problems of fracturing or flooding basements of houses, or disturbing masses of caved material within the mines, were avoided by careful control of pumping pressures. Throughout 1976, the Bureau experimented with the pumped-slurry backfilling process to expedite the procedure and minimize costs.

The Bureau of Mines has been asked by the Congress to direct its technical efforts toward resolving problems associated with the nonutilization of recoverable low-sulfur coal from refuse in the northern anthracite region of Pennsylvania. As a result the Bureau is in the initial stage of evaluating proposals to cooperate in the design, construction, and operation of an anthracite refuse preparation plant. The objective of this project will be to increase the supply of anthracite through actual recovery of coal from anthracite refuse sources located in northeastern Pennsylvania. In addition, it is hoped that the demonstration of a feasible system for reclaiming coal from anthracite refuse and the resulting economics will lead to production of anthracite at a reduced cost, thereby showing how coal from mine refuse can produce a low cost/high quality fuel.

Abandoned coal mines and oil and gas wells in some areas leak large amounts of water containing acid and other pollutants into surface waters. Fires in abandoned underground mines, coal outcrops, and refuse piles can be a source of air pollution to neighboring residents as well as threaten surface improvements and adjacent coal deposits. Mined-area restoration projects undertake to alleviate these problems. They include projects funded on 75% Federal, 25% State basis by the Appalachian Regional Commission, in-house research and demonstration projects that are funded entirely by the Bureau, and cooperative projects with the Commonwealth of Pennsylvania. The Bureau has been involved with mine water problems through monitoring, deep mine pumping, surface water diversion, water treatment methods, and oil and gas well sealing projects.

Various methods have been developed for dealing with fire problems. Outcrop fires are sometimes smothered and sometimes excavated and extinguished; underground fires in abandoned mines are controlled by placement of noncombustible and airproof barriers. A special "ponding" method has proved successful in extinguishing burning refuse banks while reducing temporary pollution problems that accompany other methods.

Several years ago the Bureau of Mines conducted a mined land survey to determine how much land was used, and reclaimed, by the mining industry during the period 1930-71, inclusive. More recently the Bureau undertook a similar survey, the results of which will be used to update data previously obtained. Unlike the earlier study, which covered land used in the production of all commodities during a 41-year period, this study focused on acquiring data on land utilized by the bituminous coal and lignite industry for 1975. Information was sought from the coal industry itself, including corroborative data from Federal and State agencies, and mining and trade associations. State agencies were also canvassed for 1975 data on administration and enforcement of surface mining regulatory procedures. Results of the survey will be disseminated through published Bureau reports.

During 1976, the Bureau held four open industry briefings under the Technology Transfer program, attracting over 500 people from the mining industry and allied fields. Technology transfer seminars are used to introduce and stimulate the transfer of specific technologic "packages," or groups of transferrable results from single research areas or combinations of related areas. During 1976, a seminar on respirable dust control was held in Pittsburgh, Pa., and Denver, Colo., in September. Exhibits and displays are widely used at major industry conferences and trade shows as another means of keeping industry abreast of ongoing research programs and accomplishments. Audiovisual presentations and hardware displays and demonstrations are employed in the technology transfer exhibit. In 1976, the exhibit was used at six such meetings, attracting estimated audiences totaling 5,500.

In-mine demonstrations and field trials are frequently important elements of the technology transfer process and are aimed at demonstrating the usefulness and applicability of new technology. Significant demonstrations and field trials completed, or ongoing, during 1976 included shallow seismic geophysical technique for detection of coal seam disturbances, prototype roof bolting machine with flexible drill and bolt bender, automatic fire detection and suppression system for mine shafts, and shield-type supports on longwall faces in Utah, New Mexico, and Illinois.

Technology News bulletins were used throughout the year to report research results ready for use by the industry. Eleven issues published during 1976 reached over 3,000 subscribers in the mining industry and related fields.

Other special publications used by the Bureau to inform industry of mining research developments include Mining Technology Research, an annual description of program funding and goals, and Mining Research Review, an annual review of selected activities and accomplishments. These are augmented by the Bureau's regular publication series, technical papers in the trade press, and presentations at major industry meetings.

The Bureau film "Safer Coal Mining Equipment," which describes the Inherently Safe Mining Systems program, was released and by the end of the year had been seen by an estimated 3,000 individuals in industry, government, and academia. The film is first in a new series of technology transfer films now being produced by the Bureau of Mines.

The licensing of technology contained in Government-owned patents provides another mechanism for technology transfer. During 1976, the Bureau's Mining Research activities were responsible for the issuance of 26 U.S. patents to the Department of the Interior. Seventeen of these inventions resulted from contracts and grants with commercial organizations and universities. Licenses to practice the technology are available to qualified parties from the Solicitor, Department of the Interior.

The major coal-producing nations of the world conduct substantial research towards improving coal mining techniques and equipment and developing more positive means to protect the miners from health and safety hazards. Of the 38 countries mining coal, 19 are known to sponsor national research and development programs. A remarkable aspect of this statistic is that about 98% of the world's coal miners are covered by the work of these research organizations.

An important international organization is the International Committee for Coal Research. The concept of this group was proposed in May 1973 by Carl E. Bagge, president of the National Coal Association at the annual meeting of the European Coal Association. Mr. Bagge's proposal resulted in an agreement to jointly sponsor a committee to seek coordination of the coal technology research efforts of the European community and the United States. The organizing committee adopted the name International Committee for Coal Research (ICCR) and agreed to sponsor the third international conference in Sidney, Australia, in October 1976.

The Bureau of Mines has been an active supporter of ICCR since its creation, and the goals of the organization reflect the mission of the Bureau to increase the production and use of coal consistent with maximum protection to the miner and the environment.

The world's major coal producers support a significant research and development program in coal mining. Collectively, this effort has resulted in substantial progress in mechanization and improved safety. With the increase in collaboration and cooperation on an international basis, even greater progress should take place at an accelerated pace. Towards this goal, the United States is committed to expand and strengthen its research and development ties with other coal-producing nations.

Metallurgy.—The general objective of the Metallurgy program is to assure a supply of mineral raw materials, essential to the Nation's security and full employment, by improving minerals and metals processing technology. Research and development is carried out to develop new technology or improve existing processes to permit the utilization of domestic low-grade ores, to develop substitute sources of raw materials, to augment the resource base through recovering byproducts now bypassed by current technology, to reduce the usage of critical materials by developing substitute materials or materials having longer life, and to improve recovery from wastes and secondary sources. Primary concerns include the development and improvement of metallurgical operations to avoid environmental degradation, to minimize energy use, and to secure the health and safety of workers and the general populace.

The Bureau's miniplant for testing and evaluating processes for recovering alumina from domestic nonbauxitic resources continued to operate at Boulder City, Nev. This cooperative project, with the support and advice of the alumina consuming industry, considered six potential processes. These included nitric acid, hydrochloric acid (both the evaporative and sparging crystallization options), and sulfurous acid processes for the extraction of alumina from clay and processes for treating anorthosite, alunite, and dawsonite. A firm under Bureau of Mines contract was to evaluate the major processes for commercial feasibility studies, make a preliminary pilot plant design for the process selected for further development.

Curtailment of natural gas deliveries to taconite pelletizing plants of the Lake Superior region was the stimulus for Bureau of Mines investigations of the induration of iron ore pellets using substitute fuels. A variety of low-rank coals were being tested using a cyclone burner to remove the coal ash as a slag externally and thereby prevent contact of the ash with the pellets. A californium-252 source/gamma ray analyzer was being used for continuous monitor flotation pilot plant slurries during a series of beneficiation tests on Mesabi taconite at the Bureau Twin Cities Metallurgy Research Center. The californium-252 system was found to be accurate enough to be used for the direct determination of iron analyses and has shown potential for use as a process control device.

With the depletion of sulfide ores, laterite oxide deposits are being increasingly utilized as a source of nickel. Under a Bureau of Mines contract, Phase I of a study was completed to determine the technical and economic feasibility of the Bureau's extraction process utilizing low-grade domestic western laterite ores. The study, based on a 5,000- ton-per-day commercial scale plant for extracting nickel, cobalt, and copper, found that the process was technically feasible and, depending upon financing structure, could provide a modest return on equity. The report, (OFR 65-76) is available for inspection at the Bureau's Metallurgy Research Centers, and is available from the National Technical Information Service (PB 256 574/AS).

A recent development by the Bureau of Mines was an improvement on established cyanide-leaching procedures for gold- and silver-bearing ores. A solution of ethyl alcohol and alkaline cyanide is used to strip loaded carbon, thereby reducing the time required for this key step without reducing effectiveness. Procedures were developed for separating smaller amounts of silver from gold-laden solutions. A portable carbon stripping unit for gold-silver recovery from activated carbon was being field tested.

The Bureau of Mines was supporting research to apply recent developments in membrane technology to the liquid-liquid extraction and separation of metals from solution. Laboratory research, conducted under a Bureau contract, demonstrated that copper can be concentrated from ore leach liquor using active transport through specially prepared membranes. The special microporous membranes employed were fabricated to contain a water-immiscible extractant system in the pores. The complexing agent in the organic phase was selected to specifically extract copper ions; it served as a "shuttle" to transport metal ions across the membrane in one direction and hydrogen ions in the opposite direction. The counterflow of hydrogen ions is the driving force to separate and concentrate the metal ions in the second (aqueous) phase on the other side of the membrane. A bench-scale unit was under construction to permit evaluation of potential scale-up problems, including possible membrance fouling and reagent loss. Laboratory studies were underway to select and optimize the extractant systems in the membranes for extracting nickel and uranium.

Viburnam Trend lead ores contain 4,500 tons of cobalt and nickel which is discarded annually with mill tailings and smelter residues. Bureau of Mines beneficiation studies were developing procedures to concentrate the cobalt and nickel, which is contained in the mineral siegenite, in one of the byproducts and to extract and win these critical metals from the byproduct.

The Bureau of Mines was planning to accelerate development of an electrolytic procedure for recovering lead from galena under a cooperative agreement with major lead producers. The new procedure, which has already shown promise in the laboratory, is to be explored using continuous process development facilities. In the procedure, galena is leached with a hot solution of ferric chloride and sodium chloride. Elemental sulfur is recovered and lead chloride crystals are dried, melted, and electrolyzed to produce molten lead and chlorine gas. The chlorine gas can be recycled to make more ferric chloride for further leaching.

Recent advances in the development of electroslag melting have stimulated interest in the process among metal producers. Bureau of Mines Bulletin 669, "The Electroslag Melting Process," is a timely review of this technology, including choice of fluxes and applications to reactive metals, base metals, ferrous alloys, superalloys, and refractory metals. Important basic mechanisms such as electrochemistry, thermochemistry, and heat transport are also described.

After intensive testing of the potash flotation system developed by the Bureau, the system was incorporated into the operations of a firm near the Great Salt Lake. Formerly the firm was able to use only the high-grade salts deposited as a result of solar evaporation of Great Salt Lake brine for processing into fertilizer. The Bureau's method converts nonfloatable kainite ($KCl \cdot MgSO_4 \cdot 3H_2O$) to a salt which can be floated using fatty acids. The new plant treats evaporites averaging 6% K_2O to recover 80% of the potash in concentrates assaying more than 14% K_2O. In a related development a procedure was found for recovering much of the saturated potash brine that has been lost with the slime during the beneficiation of potash ores.

The Bureau developed a new method for preparing molds for casting titanium that reduces cost and uses less energy. Because of titanium's chemical reactivity at liquid metal temperatures, there are few candidates for titanium molding materials: Graphite, high-cost ceramics, or refractory metals. The Bureau of Mines developed low-reactivity zircon molds with silicate binders; the sand may be reused through many cycles. Curing schedules are low (250° C) compared with those of industry (950° C), reflecting an important energy saving. The surfaces of the titanium castings produced by the Bureau method are similar to other metal castings used for utility hardware, such as pipefittings and pump housings.

Secondary Resources Recovery and Pollution Abatement.—Waste glass from the Bureau's College Park Raw Refuse Pilot Plant was incorporated into two 5-foot sections of glass-polymer-composite sewer pipe by the Brookhaven National Laboratory. In December 1975 these sections were installed in the sewer system of an industrial area of Newark, N.J., containing high-acid waste water. In September 1976, an inspection by remote television camera showed no evidence of pipe distortion or failure, infiltration through joints or pipe wall, and no deposits. Periodic inspections are to continue. This study was part of an effort to develop a market for products of municipal refuse plants.

Bureau of Mines Report of Investigations 8123 describes a new method for processing lead battery scrap that eliminates nearly all of the sulfur dioxide emission produced when normal reverberatory or blast furnace methods are used. The patented method employs a hydrometallurgical step to convert lead sulfate to lead oxide and calcium sulfate. The lead oxide is then reduced by carbon, and the calcium sulfate removed with a flux. This promising nonpolluting method for recycling battery scrap has lead recoveries as high as 97%.

Pilot plant tests of the citrate process for recovering of sulfur from smelter waste gases were concluded at a lead smelter in Kellogg, Idaho. The plant, which treated 1,000 to 1,200 standard cubic feet per minute or a gas stream containing 0.3% to 0.5% SO_2, provided engineering data on gas conditioning, SO_2 absorption, sulfur precipitation, sulfur recovery, and H_2S generation. Consistent SO_2 removal efficiencies in excess of 98% were achieved. A $12.7 million cost-sharing agreement was signed by the Bureau of Mines and St. Joe Minerals Corp. to demonstrate the Bureau's Citrate Process for scrubbing the air pollutant, sulfur dioxide (SO_2), out of powerplant flue gas. The agreement will test the Bureau's process for removing SO_2 in flue gas from a 50-megawatt coal-fired boiler at St. Joe's George F. Weaton powerplant in Monaca, Pa.

Under a cooperative program with the Florida phosphate mining industry, the Bureau was investigating methods for dewatering and stabilizing waste slimes from processed ores before impoundment of the slimes. The most promising result to date stems from a Bureau-developed flocculating-dewatering technique: A polymer of polyethylene oxide used as the flocculant and a special mechanical handling system dewatered slimes at a rapid rate. Whereas years are required to thicken the slime using the conventional storage system, only minutes are needed with the new scheme. This relatively simple system, which can be adapted for in-line processing, requires mixing the slime with the flocculant and conveying the slurry through a rotating trommel-like, wire mesh screen to remove water and discharge a thick, solid mass. In small-scale, continuous tests, retention periods of about 5 minutes yielded 25% to 35% solid products from feeds containing only 2% to 5% solids.

As a means of avoiding the slime disposal problem inherent in the present method for treating Florida land-pebble phosphate matrix and to recover phosphate now lost in beneficiation to slimes, the Bureau of Mines has been studying the direct sulfuric acid digestion of the phosphate matrix. Tests showed that about 90% of the P_2O_5 could be extracted to form sandy filter cakes, comprised mostly of quartz and gypsum, which appear suitable for backfilling. Unfortunately, the product acid produced by direct digestion sometimes contains high levels of aluminum and iron. Procedures are being worked out for reducing the levels of these contaminants to enhance acid stability during storage and transportation.

The Bureau of Mines constructed and operated a miniplant to test its laboratory-developed technology for recovering aluminum metal and aluminum oxide from the salt slag generated during treatment of aluminum dross by the secondary aluminum industry. The Bureau procedure combines leaching, screening, and filtering to separate the slag into an aluminum-rich fraction, an aluminum oxide fraction, and brine solution. The fluxing salts (NaCl-KCl) are recovered from the brine by submerged combustion evaporation. The salts and the recovered metal can then be recycled to an aluminum dross treatment furnace.

Preliminary evaluation of the durability and stiffness of sulfur-asphalt-concrete mixtures developed by the Bureau suggest that they may be able to last at least 15 years under heavy traffic conditions. The sulfur-bearing material can be formulated to have twice the dynamic stiffness of conventional paving thereby permitting placement of thinner road sections with a corresponding savings in raw materials. Sulfur-substituted asphalt paving was found in Bureau studies to be less susceptible to attack by gasoline, jet fuels, and diesel oil than is conventional bituminous concrete. Long-term wear and weathering tests were underway at a number of heavily trafficked road and airport locations.

The loss of critical metal values in stainless steel wastes and ferroalloy fumes prompted Bureau of Mines research to develop technology for recycling these wastes. In the Bureau-developed procedure the various stainless steel wastes are pelletized with 10% coke breeze and 5% portland cement. The pellets are reduced in an electric-arc furnace using a second stage ferrosilicon addition which is required to complete the reduction of chromium.

Approximately 1% to 2% of the charge in electric furnace steelmaking comes off as particulates. This flue dust is a rich source of zinc (values are substantially higher than in ore), but although there are several processes for recovering the metal, none are considered economic in the United States. Bureau of Mines Report of Investigations 8209, "Electric Furnace Steelmaking Dusts—A Zinc Raw Material" reviews extraction technology and presents results of Bureau of Mines reduction-volatilization tests on pelletized electric furnace dusts that achieved high recoveries of zinc. The data are sufficiently encouraging to warrant consideration of electric furnace dusts as raw material for zinc smelters.

Microscopic mineral particles were studied using specialized scientific disciplines that can clearly identify such potentially harmful substances as asbestos and distinguish them from thousands of other mineral particles. These studies were being performed by the Particulate Mineralogy Unit established in 1976 at the College Park (Maryland) Metallurgy Research Center of the Bureau of Mines. The new research unit utilizes the Bureau's recognized expertise in particulate mineralogy to eliminate lack of precision with which the term "asbestos" is used, a situation having environmental and health implications. The objective of this unit is to develop a solid scientific basis for research into particle-related pollution problems and to provide technically sound information on the identification of particulates involved in regulatory and research activities of Federal, State, and local agencies. The unit has been working toward the development of new and improved analytical methods for positively identifying small particles. As part of its activities, the unit has been preparing, precisely identifying, and characterizing various fibrous minerals which are then supplied to the National Institute of Environmental Health Sciences for medical investigation. The unit itself performs no medical studies.

The Imperial Valley of California contains several large geothermal reservoirs with potentially valuable resources, the recovery of which is seriously hindered by corrosion and scaling problems. In cooperation with the Energy Research and Development Administration, Bureau researchers erected mobile laboratory facilities at the Salton Sea geothermal field near Niland, Calif. In 1976 the Salton Sea facility tested 6,400 samples for general corrosion, stress corrosion cracking, corrosion fatigue failure, and electrochemical properties. Also the solubilities of hydrogen sulfide, oxygen, carbon dioxide, and methane in geothermal brines was determined, and the role of these gases in corrosion, scaling, and mineral-recovery processes evaluated.

Economic Analysis.—The Bureau's economic research program in 1976 continued to focus on economic factors that affect the minerals sector as well as on how the mineral industries affect and are affected by conditions prevalent in the national and international economies. The purpose of this research was to provide decisionmakers with accurate, up-to-date information and analysis to use in choosing among alternative courses of action. The economic analysis program attempted to develop the general methodology necessary for such analysis, as well as information relevant to problem solving in the field of mineral economics. Major long-term research projects included the study and forecasting of demand, supply, and productivity; commodity action analyses; mineral taxation; financial analysis; mineral transportation; international trade; ocean mining; input-output analysis; mining and land use; waste recycling; measures of the role of minerals in the U.S. economy; a weekly price report on fuels and minerals; and a monthly report on major minerals. Short-term projects undertaken in 1976 included: A second round study of the methodology for determining strategic stockpile levels, analysis of the Bureau of Mines information system, a mathematical model to determine an optimal stockpile to counteract foreign-induced commodity actions, an examination of the relationship of the percentage depletion allowance to nonfuel mineral supplies, development of a computer system to estimate aluminum old scrap recovery in the United States, examination of the Federal Helium Program operating within the Bureau of Mines, consultations with officials in two States on regional economic impacts from future mining, study of a tax incentive for recycling, cost-benefit analyses, 20-year time-trend projections for domestic production of commodities, and material for the annual report of the Secretary of the Interior.

Helium.—The Bureau of Mines conducts a helium program under the Helium Act of 1960 to foster individual enterprise in production and distribution; encourage conservation; and to continue research on all phases of production, transportation, and use.

The atmosphere contains an inexhaustible supply of helium, but recovery is now economically feasible only from natural gas, primarily fuel gas. The Bureau annually extracts about 350 million cubic feet of helium from natural gas at its Keyes, Okla., plant. Unsold helium is transported by pipeline to underground storage at the Bureau's Cliffside field near Amarillo, Tex. In 1976, the Cliffside field contained about 42,000 million cubic feet of helium. Mixtures of stored helium and native gas produced from Cliffside are transported by pipeline to the Bureau's Exell, Tex., plant for processing. The Bureau has contracts with eight firms for which it stores and redelivers privately produced helium.

LEGISLATION AND GOVERNMENT PROGRAMS

Economic growth in the United States continued at a steady rate in spite of the slowdown that occurred in the second half of 1976. With the assistance of the monetary and fiscal policies established during the year, real GNP rose at an average rate of about 5-3/4%.

Tax legislation in 1976 made the first extensive changes in the tax code since 1969; in spite of this, fundamental reform and simplification of the tax code were not achieved.

Energy price increases were slowed significantly during the year; this resulted partially from the Energy Policy and Conservation Act that became effective in February 1976. Energy consumption had increased owing to the economic recovery in 1976. However, higher prices held the consumption below previously established levels. The mining industry continued to meet with environmental regulation problems resulting from legislation enacted to conserve natural resources. This includes the regulation of mining activity within the National Park System.

Legislation approved during the 94th Congress covered many areas affecting the minerals sector of industry in the United States. Summarized below are some of the more important laws enacted. Amending the Mineral Leasing Act of 1920, Public Law (P.L.) 94-377 was implemented to provide diligent development and continuous operation of coal leases on Federal lands. Public Law 94-332 and Public Law 94-385 extended the authority and funding for the Federal Energy Administration during 1976 and extended their authority into the next fiscal year. Public Law 94-493 provided a renewal and extension of the interstate compact to conserve oil and gas to prevent physical waste of this natural resource. Public Law 94-586 is designed to help alleviate the natural gas shortage in the contiguous States of the United States by transporting natural gas from Alaska. In the environmental area, Public Law 94-580 amends the Solid Waste Disposal Act to promote the protection of health and the environment and to conserve valuable material and energy resources. Public Law 94-429 provides for the regulation of mining activity within, and repeals application of mining laws to, areas of the National Park System. In establishing a public land policy, Public Law 94-579, the Bureau of Land Management Organic Act, was enacted. Public Law 94-469 requires testing and necessary use restriction on certain chemical substances under the title, "Toxic Substances Control Act." Public Law 94-455, the Tax Reform Act of 1976, has included with other sections, an amendment to the rules pertaining to limitations on percentage depletion in the case of oil and gas wells. Public Law 94-409, the "Government in the Sunshine Act," provides that meetings of Government agencies shall be open to the public. A listing of mineral-related Federal legislation signed into law during 1976 follows:

Public Law (P.L.)	Description	Signed into Law
Energy:		
94-258	Establish national petroleum reserves on public lands.	Apr. 5
94-332	Extend FEA expiration date.	June 30
94-355	Public works in Water and Power Development and Energy Research Appropriations Act.	July 12
94-370	Improve coastal zone management for energy development.	July 26
94-377	Federal Coal Leasing Amendment Act.	Aug. 4
94-385	Extend Federal Engery Administration Act of 1974.	Aug. 4
94-422	Monies paid to any State involving oil shale in public lands may be used by such State.	Sept. 28
94-493	Extend interstate compact to conserve oil and gas.	Oct. 14
94-586	Expedite decision on delivery of Alaskan natural gas.	Oct. 22

Public Law (P.L.)	Description	Signed into Law
Environmental Quality:		
94-326	Extend Marine Protection, Research, and Sanctuaries Act 2 years.	June 30
94-558	Loan guarantees for construction of treatment works under Federal Water Pollution Control Act.	Oct. 19
94-580	Provide technical and financial assistance under Resource Conservation and Recovery Act of 1976.	Oct. 21
Water Resources:		
94-228	Authorize and modify various Federal reclamation programs.	Mar. 11
94-316	Appropriation for Saline Water Conversion Program.	June 22
94-423	Appropriation for Federal reclamation programs.	Sept. 28
Public Lands:		
94-429	Regulate mining activity within National Park Service.	Sept. 28
94-456	Withdrawal of lands under Alaska Native Claims Settlement Act.	Oct. 4
94-458	Provide improved administration of National Park Service.	Oct. 7
94-486	Amend Wild and Scenic Rivers Act.	Oct. 12
94-565	Provide payments to local Governments based on boundaries on public lands.	Oct. 20
94-567	Designate certain National Park Service lands as wilderness.	Oct. 20
94-579	Establish policy under Federal Land Policy Management. Act of 1976.	Oct. 21
Health and Safety:		
94-469	Toxic substances control.	Oct. 11
94-477	Amend Natural Gas Pipeline Safety Act of 1968.	Oct. 11
94-504	Qualified individuals to hear and determine claims under Title IV of Federal Coal Mine Health and Safety Act of 1969.	Oct. 15
Taxes:		
94-455	Tax reform, 1976.	Sept. 28
Tariff and Duties:		
94-560	Continue suspension of duties on Mn ore and related products through June 30, 1979.	Oct. 19

Public Law (P.L.)	Description	Signed into Law
Transportation:		
94-280	Appropriation for highway construction.	May 5
Miscellaneous:		
94-373	Appropriation for Interior and related agencies.	July 31
94-409	Government in the Sunshine Act, meetings of Government agencies to be open to public.	Sept. 13

The acquisition cost of strategic and critical materials in the national stockpile as of December 31, 1976, was $2.5 billion having a market value of $6.0 billion. The supplemental stockpile acquisition cost was $1.1 billion with a market value of $1.9 billion and corresponding Defense Production Act stockpile figures were $0.3 billion and $0.2 billion, respectively. The total acquisition cost of these materials was $3.9 billion having a market value of $8.2 billion. In 1976, disposals from the national and supplemental stockpiles totaled $90.1 million, a decline of 16.5% from that of 1975. Including the Defense Production Act inventory and other inventory disposals, the grand total of sales commitments for mineral commodities was $102.3 million. Commodities with largest sales value were tin with $26.3 million, cobalt with $20.8 million, tungsten ores and concentrates with $14.5 million, and aluminum with $8.0 million.

In 1975-76, a major interagency review of the strategic and critical material stockpile was conducted and in August 1976 the President approved new national stockpile policies on advice from the National Security Council. A set of long-range goals for acquisition and disposal of materials to plan for the first 3 years of an emergency, as opposed to the earlier policy of 1 year, was announced on October 1, 1976.

WORLD REVIEW

World Economy.—In 1976, six major industrialized countries—Canada, France, Italy, Japan, the United Kingdom, and West Germany—showed economic turnarounds compared with 1975. All six countries experienced slowdowns in their economies to varying degrees in the second half of the year compared with the first 6 months. Some progress was made in fighting inflation in 1976, though the problem was still far from being solved. Unemployment rates in most countries remained high despite improved levels of industrial production. However, as economic activity increased, the volume of trade worldwide also rose. The volume of trade increased an estimated 11% in 1976 compared to a decline of 6% to 7% in 1975.

Real GNP growth rates for 1976 were estimated at 5.9% in Japan, 5.6% in West

Germany, 4.8% in both Canada and France, 4.5% in Italy, and 0.9% in the United Kingdom. Inventory buildups contributed to improving economic conditions in these countries, but as inventory accumulation was completed, consumer spending declined and plant and equipment expenditures were less than expected.

World oil prices continued to increase in 1976, though at a more gradual rate than the rapid rise of 1973-74. These higher fuel costs have caused continuing economic structural adjustments and led to added demands for scarce capital resources because of the need to develop alternative energy sources.

World Production.—The United Nations (UN) indexes of world mineral industry production (1970=100) for the extractive industries increased 6 index points to 121 in 1976. Within the extractive industry, the metal mining index rose 3 index points to 106, the coal index increased 1 point to 100, and the crude petroleum and natural gas index increased 9 points to 130. The mineral processing industries indexes showed increases of 9 points to 121 for base metals, 9 points to 135 for nonmetallic mineral products, and 14 points to 146 for chemicals, petroleum, and coal products. Overall industrial production as measured by the UN index rose 11 points to 136 in 1976.

World Trade.—The value of world export trade grew 4.7% to $872.5 billion in 1975 (latest data available). The value of mineral commodities entering world trade declined 3% to $253.6 billion. Internationally traded metals decreased 9.8% in value to $78.8 billion, and within this group iron and steel declined 1.3% to $45.8 billion, nonferrous metals dropped 27.7% to $18.2 billion, and all ores, concentrates, and scrap fell 6.4% to $14.7 billion. Crude nonmetal exports increased 6.8% in value to $6.3 billion. The value of mineral fuels rose by a negligible amount in 1975 to $168.6 billion.

World Prices.—(Note that all export price data, with the exception of the all crude minerals index, is for the first three quarters of the year only, because the United Nations discontinued publishing the data that would provide the series for the remainder of the year.) In 1976 mineral commodity export price indexes (1970=100) increased slightly for all crude minerals and appeared to have risen for the metal ores and fuels sectors. All crude minerals increased 16 index points to 510, and metal ores and fuels averaged 210 points and 616 points, respectively, for the first three quarters. Based on data through third quarter 1976, export prices for total minerals remained nearly constant in developed areas and averaged 595 index points in developing areas. Nonferrous base metals showed gains in both developed and developing areas, averaging 136 points and 123 points, respectively, based on the first three quarters of 1976.

Table 1.—Value of crude mineral production,[1] exports, and imports, by group

(Million dollars)

Mineral group	1972			1973			1974		
	Production	Exports[2]	Imports[2]	Production	Exports[2]	Imports[2]	Production	Exports[2]	Imports[2]
Metals and nonmetals except fuels:									
Nonmetals	6,482	152	646	7,413	280	768	r8,639	533	1,158
Metals	3,642	247	988	4,362	253	1,081	r5,501	343	[3]1,758
Total[4]	10,124	399	1,634	11,775	533	1,849	r14,140	876	[3]2,917
Mineral fuels	22,061	1,108	2,856	25,012	1,155	4,815	40,937	2,665	16,545
Grand total[4]	32,185	1,508	4,490	36,787	1,688	6,664	r55,077	3,542	[3]19,462

Mineral group	1975			1976		
	Production	Exports[2]	Imports[2]	Production	Exports[2]	Imports[2]
Metals and nonmetals except fuels:						
Nonmetals	9,516	745	r1,215	10,547	642	1,201
Metals	r5,191	372	r [3]1,618	6,086	380	[3]1,662
Total[4]	r14,709	1,117	r [3]2,832	16,644	1,022	[3]2,864
Mineral fuels	r47,559	3,557	19,912	52,545	3,255	27,668
Grand total[4]	r62,266	4,674	r [3]22,744	69,178	4,277	[3]30,532

rRevised.
[1]For details, see the "Statistical Summary" chapter of this volume.
[2]Essentially unprocessed mineral raw material.
[3]The value of imports for bauxite was not available.
[4]Data may not add to totals shown because of independent rounding.

Table 2.—Value of crude mineral production by group, 1967 constant dollars[1]

(Million dollars)

Mineral group	1972	1973	1974	1975	1976p
Metals and nonmetals except fuels:					
Nonmetals	5,762	6,219	6,095	5,338	5,628
Metals	2,861	3,070	2,956	2,640	2,860
Total	8,623	9,289	9,051	7,978	8,488
Mineral fuels	17,075	17,676	17,000	16,623	16,354
Grand total	25,698	26,965	26,051	24,601	24,842

pPreliminary.
[1]Value deflated by the index of implicit unit value.

Table 3.—Indexes of the physical volume of mineral production, by group and subgroup[1]

(1967=100)

	1972	1973	1974	1975	1976[p]
METALS					
Ferrous	98.4	116.0	108.3	96.2	99.8
Nonferrous:					
Base	162.8	166.5	159.3	142.7	158.0
Monetary	102.7	94.5	86.9	86.2	85.1
Other	112.6	114.8	122.8	119.2	142.8
Average	151.1	153.6	148.4	134.8	149.8
Average, all metals	127.5	136.8	130.4	117.5	127.4
NONMETALS					
Construction	111.7	120.8	115.2	99.5	104.9
Chemical	108.7	112.2	121.3	112.2	117.2
Other	112.2	122.7	128.6	109.4	124.1
Average	111.0	119.0	117.2	102.8	108.6
FUELS					
Coal	105.9	105.1	107.1	114.9	120.2
Crude oil and natural gas	111.4	109.3	104.1	98.7	96.6
Average	111.2	109.3	105.4	102.3	101.4
Average, all minerals	112.7	114.1	110.4	103.8	105.5

[p]Preliminary.
[1]Historical table of this series in Bureau of Mines Minerals Yearbook, 1971.

Table 4.—Federal Reserve Board indexes of industrial production for mining and selected minerals manufacturing

(1967=100)

	1972	1973	1974	1975	1976[p]
Mining:					
Coal	104.2	104.4	[r]114.0	113.4	116.9
Oil and gas extraction:					
Crude oil	107.3	104.4	99.8	95.0	92.2
Natural gas	126.4	125.9	121.4	110.9	109.1
Average[1]	110.0	108.9	[r]104.4	113.3	112.0
Average coal, oil, gas	109.2	108.3	[r]105.7	105.8	112.8
Metal	120.9	130.8	[r]121.7	115.8	122.8
Stone and earth minerals	98.1	109.5	[r]101.8	107.0	118.3
Average	107.3	118.1	[r]109.9	109.8	120.1
Average mining	108.8	110.3	[r]106.5	112.8	114.1
Manufacturing:					
Primary metals	113.1	127.0	[r]97.2	96.4	108.0
Iron and steel	107.1	121.7	[r]96.1	95.8	104.4
Nonferrous metals and products	123.6	136.5	131.2	99.3	114.4
Clay, glass, stone products	118.6	129.8	[r]108.8	117.9	135.8
Average industrial production	[r]119.7	[r]129.8	[r]129.3	117.8	129.4

[p]Preliminary. [r]Revised.
[1]Includes natural gas liquids and oil and gas drilling.

Source: Federal Reserve System, Board of Governors. Federal Reserve, Industrial Production, Statistical Release, Dec. 14, 1973, Dec. 13, 1974, Apr. 15, 1975, Feb. 13, 1976, Apr. 15, 1976, Feb. 15, 1977, and June 15, 1977.

Table 5.—Federal Reserve Board monthly indexes of mining production, seasonally adjusted

(1967=100)

Month	Total mining[1]		Coal, oil, gas		Coal		Oil and gas extraction				Metal, stone, earth minerals[3]		Metal mining		Stone and earth minerals	
							Total[2]		Crude oil							
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
January	107.0	113.6	103.9	112.3	111.3	111.2	102.9	112.5	96.3	94.8	119.1	119.1	133.8	122.2	109.0	117.1
February	108.6	112.7	106.8	110.0	117.5	109.6	105.0	110.1	97.7	91.2	116.2	121.7	131.1	124.2	106.1	120.0
March	108.9	113.9	107.7	112.2	117.4	114.4	106.1	111.9	95.9	93.2	113.4	120.5	125.4	122.3	105.1	119.3
April	108.5	113.5	107.4	111.7	112.2	114.4	106.6	111.3	95.0	93.1	113.3	120.3	125.8	124.3	104.7	117.5
May	105.9	113.0	105.8	111.9	113.6	119.2	104.5	110.8	94.3	91.1	106.2	117.3	114.8	118.3	100.4	116.7
June	106.3	114.4	107.6	113.7	120.4	122.7	105.5	112.3	95.7	92.5	101.5	117.2	110.6	118.3	95.3	116.5
July	106.4	112.5	106.7	111.0	120.6	104.8	104.5	112.0	95.5	92.0	105.0	118.6	110.3	121.6	101.4	116.5
August	105.0	114.4	104.4	112.3	105.7	112.6	104.2	112.3	94.7	91.9	107.2	122.4	119.2	127.5	98.9	119.0
September	105.3	115.7	104.8	114.4	113.6	121.3	103.4	113.3	93.6	93.2	107.2	121.0	118.5	123.6	99.5	119.2
October	106.4	116.7	106.1	115.2	114.6	132.3	104.8	112.5	94.6	91.4	108.0	123.0	119.8	127.4	100.0	120.0
November	106.9	116.2	105.9	114.1	119.9	125.1	103.8	112.4	93.9	91.2	110.0	124.1	122.1	128.1	101.7	121.4
December	105.4	116.2	104.7	114.3	107.8	125.9	104.3	112.8	93.9	91.5	108.2	123.0	120.9	130.4	99.6	117.9
Average	106.6	114.1	105.8	112.8	113.8	116.9	104.5	112.0	95.0	92.2	109.8	120.1	121.7	122.8	101.7	118.3

[1]Includes fuels.
[2]Includes natural gas liquids and oil and gas drilling.
[3]Data source has changed format, this is now calculated on a weighted average basis.

Source: Federal Reserve System, Board of Governors. Federal Reserve, Industrial Production, Statistical Release, Mar. 16, 1976, Apr. 15, 1976, Feb. 15, 1977, Apr. 15, 1977, and June 15, 1977.

Table 6.—Net supply of principal minerals by component

(Thousand short tons of mineral content, unless otherwise stated)

Commodity	Total net supply		Percent change	Components as percentage of gross supply[1]						Exports as percentage of gross supply	
				Primary shipments		Old scrap		Imports			
	1975	1976		1975	1976	1975	1976	1975	1976	1975	1976
FERROUS METALS											
Iron ore ---- thousand long tons	119,901	118,174	-1.4	62	63	--	--	38	37	2	2
Pig iron	79,658	87,079	+9.3	99	99	--	--	1	1	([2])	([2])
Steel ingot	125,155	137,425	+9.8	90	91	--	--	10	9	3	3
Chromite (Cr_2O_3)	420	409	-2.6	--	--	--	--	100	100	[e]9	23
Cobalt ---- thousand pounds	17,627	31,218	+77.1	66	50	--	--	34	50	9	5
Manganese	561	521	-7.1	--	--	--	--	100	100	27	20
Molybdenum (ore and concentrate) ---- thousand pounds	45,126	54,146	+20.0	98	98	--	--	2	2	58	54
Nickel	166	169	+1.8	[r]9	7	[r]9	6	[3]82	87	[r]15	22
Tungsten ---- thousand pounds	10,742	9,441	-12.1	46	53	--	--	54	47	11	15
OTHER METALS											
Aluminum	4,327	4,931	+14.0	81	79	[r]7	8	12	14	[r]9	9
Antimony	36	42	+16.7	2	1	[e]46	[e]47	52	52	1	1
Cadmium	3	6	+100.0	24	43	--	--	76	57	6	4
Copper	2,037	2,472	+21.4	[r]69	64	[r]18	17	[3]13	19	1	1
Lead	1,403	1,564	+11.5	44	39	46	46	10	15	1	([2])
Mercury ---- 76-pound flasks	58,789	69,957	+19.0	12	33	14	5	74	62	1	1
Platinum group ---- thousand troy ounces	2,739	3,973	+45.1	39	36	8	5	53	59	19	11
Tin ---- thousand long tons	56	54	-3.6	--	--	27	20	73	80	7	4
Titanium concentrate (TiO_2):											
Ilmenite and slag	739	715	-3.2	55	52	--	--	45	48	--	--
Uranium concentrate (U_3O_8)	13	20	+53.8	92	70	--	--	8	30	([2])	--
Zinc	1,044	1,357	+30.0	45	36	[r]6	5	50	60	1	([2])
NONMETALS											
Asbestos	602	726	+20.6	16	15	--	--	84	85	6	6
Barite, crude	1,952	2,139	+9.6	[r]68	58	--	--	[r]32	42	--	--
Bromine ---- thousand pounds	403,577	435,445	+7.9	100	100	--	--	([2])	([2])	1	1
Clays	47,111	50,733	+7.7	100	100	--	--	([2])	([2])	5	5
Fluorspar, finished	1,189	1,078	-9.3	12	17	--	--	88	83	([2])	([2])
Gypsum	20,961	23,967	+14.3	74	74	--	--	26	26	([2])	1
Mica (excluding scrap)	117	117	--	93	96	--	--	7	4	5	6
Phosphate rock (P_2O_5)	11,110	11,837	+6.5	100	100	--	--	([2])	([2])	26	22
Potash (K_2O equivalent)	5,112	6,149	+20.3	36	35	--	--	64	65	13	13
Salt, common	42,913	47,536	+10.8	93	91	--	--	7	9	3	2
Sand and gravel ---- million tons	787	882	+12.1	100	100	--	--	([2])	([2])	([2])	([2])

Stone, crushed ---- do----	900	899	-.1	100	100	--	--	(2)	(2)	(2)	(2)
Sulfur, all forms ---- thousand long tons--	10,603	10,768	+1.6	84	86	--	--	16	14	11	11
Talc and allied minerals ----	830	869	+4.7	98	98	--	--	2	2	16	20

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Net supply is sum of primary shipments, old scrap, and imports minus exports. Stockpile disposals are included in primary shipments. Gross supply is the total before subtraction of exports.
[2]Less than 1/2 unit.
[3]Erroneously reported in previous year.

Table 7.—Shipments, net new orders, and yearend unfilled orders for selected mineral processing industries

(Million dollars)

Year and month	Shipments			Net new orders[1]			Unfilled orders at end of period[1]		
	Primary metals	Blast furnaces and steel mills	All other primary metals[2]	Primary metals	Blast furnaces and steel mills	All other primary metals[2]	Primary metals	Blast furnaces and steel mills	All other primary metals[2]
1972	57,941	28,109	29,832	60,143	29,813	30,330	7,964	5,008	2,686
1973	72,027	35,260	36,767	78,642	39,913	38,729	14,844	9,884	4,960
1974	93,673	47,424	46,249	97,233	49,036	48,197	20,698	13,751	6,947
1975	78,959	40,210	38,749	71,792	35,779	36,013	14,742	9,287	5,455
1976[p]	88,826	45,139	43,687	90,047	45,848	44,199	16,004	9,993	6,011
1976:									
January	6,544	3,517	3,027	6,674	3,701	2,973	14,567	9,461	5,106
February	6,922	3,574	3,348	6,812	3,365	3,447	14,620	9,366	5,254
March	7,644	3,985	3,659	7,787	3,864	3,923	15,011	9,456	5,555
April	7,544	3,787	3,757	7,328	3,530	3,798	15,229	9,420	5,809
May	8,031	4,043	3,988	8,726	4,968	3,758	16,260	10,475	5,785
June	8,318	4,275	4,043	8,158	4,251	3,907	16,692	10,690	6,002
July	7,110	3,689	3,421	7,918	3,997	3,921	16,846	10,650	6,196
August	7,577	3,799	3,778	7,340	3,581	3,759	16,330	10,323	6,007
September	7,844	3,925	3,919	7,556	3,649	3,907	16,140	10,028	6,112
October	7,454	3,641	3,813	7,019	3,485	3,534	15,804	9,832	5,972
November	7,086	3,547	3,539	7,529	3,650	3,879	16,051	9,768	6,283
December	6,752	3,357	3,395	7,252	3,808	3,444	16,004	9,993	6,011

[p]Preliminary.
[1]Monthly figures are seasonally adjusted and may not add to totals.
[2]"All other primary metals" obtained by subtracting blast furnaces and steel mills from primary metals figures.

Source: U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. V. 54 and 55, No. 2, February 1974 and 1975, pp. S-5, S-6, S-7; v. 56 and 57, No. 3, March 1976 and 1977, pp. S-5, S-6, S-7.

Table 8.—Index of nonfuel mineral stocks at yearend

(1967=100)

	1972	1973	1974	1975	1976[p]
Crude minerals at producers:					
Metals	143	95	76	91	102
Iron ore	113	84	73	95	108
Other ferrous	428	208	130	104	90
Nonferrous	78	63	53	55	71
Nonmetals	138	129	125	171	191
Total	141	110	98	126	141
Minerals at manufacturers, consumers, and dealers:					
Metals	[1]108	[1]98	[1]117	[1]134	132
Iron	88	79	79	93	101
Other ferrous	135	99	102	132	111
Base nonferrous	99	89	131	153	152
Other nonferrous	[1]126	[1]117	[1]140	[1]155	148
Nonmetals	94	91	100	91	84
Total	[1]108	[1]98	[1]116	[1]131	130

[p]Preliminary.
[1]Revised aluminum series.

Table 9.—Physical stocks of mineral energy resources and related products at yearend

(Producers' stocks, unless otherwise indicated)

Fuel	1972	1973	1974	1975	1976[p]
Coal and related products:					
Bituminous coal and lignite[1] short tons	116,500,000	103,022,000	95,528,000	127,115,000	133,673,000
Coke do	2,941,000	1,184,000	935,000	4,996,000	6,487,000
Petroleum and related products:					
Carbon black thousand pounds	237,695	230,325	293,903	231,695	213,594
Natural gasoline, plant condensates, isopentane thousand barrels	6,075	7,835	7,550	7,382	8,128
Crude petroleum and petroleum products[2] do	[3]958,979	[3]1,008,307	[3]1,073,646	[3]1,132,955	1,111,810
Crude petroleum do	246,395	[3]242,478	265,020	271,354	285,471
Motor gasoline do	[3]212,894	[3]209,478	[3]218,410	[3]234,978	231,432
Special naphthas do	5,232	[3]4,521	[3]5,720	[3]4,377	4,441
Liquefied gases[3] do	85,717	[3]98,641	[3]112,542	[3]125,148	116,295
Distillate fuel oil do	154,319	[3]196,461	[3]200,068	[3]208,833	185,986
Residual fuel oil do	55,216	53,480	59,694	74,126	72,344
Petroleum asphalt do	[3]21,638	15,024	21,370	22,794	19,375
Other products do	[3]177,568	[3]188,224	[3]190,822	[3]191,345	196,466
Natural gas[4] billion cubic feet	3,523	3,906	3,969	[5]4,400	4,239

[p]Preliminary.
[1]Industrial consumers and retail yards.
[2]Includes natural gas liquids and products at bulk terminals and in pipelines.
[3]Incorrectly reported in previous year.
[4]Includes ethane.
[5]Adjusted upward by 123 billion cubic feet to conform to new data source.

Table 10.—Seasonally adjusted book value of product inventories for selected mineral processing industries

(Million dollars)

End of year or month	Petroleum and coal products	Stone, clay, glass products	Primary metals: Blast furnaces and steel mills	Primary metals: All other primary metals[1]	Primary metals: Total
1972: December	2,300	2,463	5,268	4,390	9,658
1973: December	2,626	2,813	4,672	4,684	9,356
1974: December	3,925	3,721	5,747	6,114	11,861
1975: December[r]	4,710	3,848	8,483	7,044	15,527
1976:[p]					
December	5,148	4,194	10,179	7,150	17,329
January	4,713	3,848	8,498	6,794	15,292
February	4,732	3,823	8,559	6,742	15,301
March	4,741	3,769	8,766	6,780	15,546
April	4,552	3,803	8,870	6,785	15,655
May	4,650	3,869	9,078	6,801	15,879
June	4,835	3,885	9,233	6,762	15,995
July	4,872	3,934	9,452	6,773	16,225
August	4,833	4,002	9,709	6,776	16,485
September	5,043	3,998	9,787	6,873	16,660
October	5,058	4,092	10,100	7,013	17,113
November	5,053	4,130	10,072	7,106	17,178

[p]Preliminary. [r]Revised.
[1]"All other primary metals" figure obtained by subtracting blast furnaces and steel mills figure from total primary metals figure.

Source: U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. V. 54 and 55, No. 2, February 1974 and 1975, p. S-6; v. 56 and 57, No. 3, March 1976 and 1977, p. S-6.

Table 11.—Value of selected minerals and mineral products imported and exported by the United States in 1976, by commodity group and commodity[1]

(Thousand dollars)

SITC code[2]	Commodity	Exports	Imports
	Minerals, nonmetallic (crude):		
271	Fertilizers, crude	329,160	12,674
273	Stone, sand and gravel	46,550	28,935
274	Sulfur and unroasted iron pyrites	60,351	59,619
275	Natural abrasives (including industrial diamonds)	62,700	63,034
276	Other crude minerals	293,299	301,930
	Total[3]	792,060	466,194
	Metals (crude and scrap):		
281	Iron ore and concentrates	82,192	980,347
282	Iron and steel scrap	634,476	42,757
283	Ores and concentrates of nonferrous base metals	260,034	892,550
284	Nonferrous metal scrap	238,898	221,185
285	Silver, platinum, platinum-group metal ores and concentrates	44,471	109,109
286	Uranium and thorium ores and concentrates	24,432	430
	Total[3]	1,284,503	2,246,381
	Mineral energy resources and related products:		
321	Coal, coke, briquets (including peat)	2,988,232	158,731
331	Petroleum, crude and partly refined	27,129	26,346,781
332	Petroleum products, except chemicals	970,811	5,408,528
341	Gas, natural and manufactured	239,937	2,014,679
	Total[3]	4,226,109	33,928,720
	Chemicals:		
	Inorganic chemicals:		
513	Elements, oxides, halogen salts	643,887	804,419
514	Other inorganic chemicals	365,711	128,704
515	Radioactive and associated materials except uranium and thorium	466,679	659,053
521	Mineral tar and crude chemicals from coal, petroleum, natural gas	74,819	11,403
	Total[3]	1,551,096	1,603,579
	Minerals, nonmetallic (manufactured):		
661	Lime, cement, fabricated building material, except glass and clay	54,684	113,865
662	Clay and refractory construction materials	138,283	81,573
663	Mineral manufactures, not elsewhere specified	203,024	97,431
	Total	395,991	292,869
	Metals (manufactured):		
671	Pig iron, spiegeleisen, sponge iron, iron and steel powder and shot, ferroalloys	73,182	535,659
672	Iron or steel ingots and other primary forms	46,610	52,812
673	Iron or steel bars, rods, angles, shapes, sections	153,227	863,580
674	Iron or steel universals, plates, sheets	337,538	1,915,102
675	Iron or steel hoops and strips	100,799	72,409
676	Iron or steel rails and railway track construction materials	61,579	18,989
677	Iron or steel wire (excluding wire rod)	36,191	214,061
678	Iron or steel tubes, pipes, fittings	776,541	819,821
679	Iron or steel castings and forgings, unworked	318,492	20,990
681	Silver, platinum, platinum-group metals	96,710	559,498
682	Copper and copper alloys	281,672	776,792
683	Nickel and nickel alloys	158,078	526,302
684	Aluminum and aluminum alloys	466,386	549,854
685	Lead and lead alloys	5,321	63,495
686	Zinc and zinc alloys	11,199	502,869
687	Tin and tin alloys	4,629	329,689
688	Uranium and thorium metals and alloys	146	117
689	Miscellaneous nonferrous base metals	158,533	185,518
	Total[3]	3,086,833	8,007,563
	Grand total	11,336,592	46,545,306

[1]Data in this table are for the indicated SITC numbers only, and therefore may not correspond to the figures classified by commodity in the "Statistical Summary" chapter of this volume.
[2]Standard International Trade Classification.
[3]Import data may not add to totals shown because of independent rounding.

Source: U.S. Department of Commerce, Bureau of the Census.

Table 12.—Percentage distribution of the value of exports of selected minerals and mineral fuels and related products in 1976, by area of destination

SITC code[1]	Commodity	North America[2]	South America	Europe excluding centrally planned economies	Europe, centrally planned economies[3]	Asia, excluding centrally planned economies	Asia centrally planned economies[4]	Africa	Oceania
271	Fertilizers, crude	23	9	31	4	33	--	([5])	([5])
273	Stone, sand and gravel	82	3	9	1	5	--	1	1
274	Sulfur and unroasted iron pyrites	3	14	78	--	([5])	--	([5])	4
275	Natural abrasives, including industrial diamonds	13	5	62	1	14	--	1	4
276	Crude minerals, not elsewhere specified	27	5	41	1	23	--	2	2
281	Iron ore and concentrates	99	([5])	([5])	--	([5])	--	([5])	--
282	Iron and steel scrap	15	2	48	([5])	34	1	1	([5])
283	Ores and concentrates of nonferrous base metals	6	3	71	1	19	--	([5])	([5])
284	Nonferrous metal scrap	13	3	37	--	47	--	([5])	([5])
286	Uranium and thorium ores and concentrates	14	--	86	--	--	--	--	--
321	Coke, coal, briquets, including peat	26	6	31	1	35	--	1	([5])
331	Petroleum, crude and partly refined	100	([5])	--	--	--	--	--	--
332	Petroleum products, except chemicals	21	9	39	2	22	([5])	4	3
341	Gas, natural and manufactured	62	([5])	([5])	--	38	--	([5])	([5])
513	Inorganic chemical elements, oxides, halogen salts	33	20	20	1	15	([5])	6	6
514	Other inorganic chemicals	36	15	22	1	16	([5])	4	5
515	Radioactive and associated materials	2	([5])	64	([5])	34	--	([5])	([5])
521	Mineral tar and crude chemicals from coal, petroleum, natural gas	14	9	64	([5])	9	--	3	1
661	Lime, cement, fabricated building materials except glass and clay	61	6	20	1	11	--	1	([5])
662	Clay and refractory construction materials	51	17	12	4	10	([5])	5	3
663	Mineral manufactures, not elsewhere specified	42	6	25	8	14	([5])	2	4
671	Pig iron, sponge iron, iron or steel powders and shot, ferroalloys	46	7	26	1	18	--	2	1
672	Iron and steel ingots and other primary forms	56	17	15	--	11	--	1	([5])
673	Iron and steel bars, rods, angles, shapes, sections	50	12	18	([5])	17	--	2	1
674	Iron and steel plates and sheets	35	18	22	5	16	([5])	4	1
675	Iron and steel hoop and strip	32	9	48	([5])	5	--	2	4
676	Iron and steel rails and railway track construction material	46	27	([5])	1	26	([5])	1	([5])
677	Iron and steel wire (except insulated electric)	45	12	22	2	7	--	12	1
678	Iron and steel tubes, pipes, fittings	31	12	13	4	29	1	8	2
679	Iron and steel castings and forgings (rough)	87	2	7	([5])	2	([5])	1	1
681	Silver, platinum, platinum-group metals	16	3	29	1	51	([5])	1	1
682	Copper and copper alloys	21	6	62	([5])	9	([5])	1	([5])
683	Nickel and nickel alloys	25	5	63	1	4	--	([5])	2
684	Aluminum and aluminum alloys	43	8	25	([5])	15	6	3	1

Table 12.—Percentage distribution of the value of exports of selected minerals and mineral fuels and related products in 1976, by area of destination —Continued

SITC code[1]	Commodity	North America[2]	South America	Europe excluding centrally planned economies	Europe, centrally planned economies[3]	Asia, excluding centrally planned economies	Asia centrally planned economies[4]	Africa	Oceania
685	Lead and lead alloys	48	10	19	3	17	--	2	3
686	Zinc and zinc alloys	31	5	47	--	8	--	6	3
687	Tin and tin alloys	47	26	13	--	14	--	(5)	(5)
688	Uranium and thorium and their alloys	59	4	30	4	4	--	--	--
689	Base metals and alloys not elsewhere specified	19	8	50	1	21	--	(5)	1

[1]Standard International Trade Classification.
[2]Includes Trinidad and the Netherlands Antilles.
[3]The U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Romania, Yugoslavia, Estonia, Latvia, Lithuania.
[4]The People's Republic of China, North Korea, Vietnam, Laos, Cambodia, Mongolia.
[5]Less than 1/2 unit.

Source: U.S. Department of Commerce, Bureau of the Census.

Table 13.—Percentage distribution of imports of principal minerals and mineral fuels and related products in 1976, by area of origin

SITC code[1]	Commodity	North America[2]	South America	Europe, excluding centrally planned economies	Europe, centrally planned economies[3]	Asia, excluding centrally planned economies	Asia, centrally planned economies[4]	Africa	Oceania	Undistributed
2713000	Phosphate, crude and apatite	98	--	--	--	--	--	--	--	2
2732100	Gypsum	99	--	1	--	--	--	--	--	([5])
2743000	Sulfur	99	--	--	--	1	--	--	--	([5])
2752400	Natural abrasives	--	--	79	--	--	--	12	--	9
2762200	Graphite, natural	29	--	10	4	23	11	19	--	4
2762500	Magnesia, refractory and caustic-calcined, and crude magnesite	--	--	91	--	6	--	--	1	1
2763000	Salt	90	3	6	--	--	--	--	--	1
2764000	Asbestos	89	--	([5])	2	--	--	8	--	([5])
2765200	Mica, including scrap	--	31	--	--	51	--	8	--	9
2765420	Fluorspar	58	--	24	--	3	--	15	--	([5])
2769300	Barite, crude	15	20	45	--	--	--	20	--	1
2769500	Talc	14	--	53	--	29	--	--	--	4
2810000	Iron ore and concentrates	64	29	1	([5])	([5])	--	4	1	([5])
2820000	Iron and steel scrap	95	--	3	([5])	1	--	--	([5])	([5])
2831100	Copper ores and concentrates	68	6	--	--	21	--	1	4	([5])
2833000	Bauxite	65	21	--	--	--	([5])	13	--	([5])
2834000	Lead ores and concentrates	77	10	--	--	--	--	--	13	([5])
2835000	Zinc ores and concentrates	98	1	([5])	--	--	--	--	1	([5])
2836000	Tin ores and concentrates	--	100	--	--	--	--	--	--	--
2837000	Manganese ores and concentrates	3	24	--	--	--	--	56	16	--
2839100	Chrome ores	--	([5])	38	30	9	--	22	--	([5])
2839200	Tungsten ores and concentrates	32	30	8	--	17	7	2	3	([5])
2839310	Tantalum, molybdenum, vanadium ores and concentrates	59	5	5	--	6	--	11	13	1
2839320, 2839330	Titanium ores and concentrates	6	--	--	--	1	--	--	93	([5])
2839340	Zirconium ores	4	--	--	--	--	--	--	96	([5])
2839910	Antimony ores and needles	28	28	([5])	--	--	--	43	--	([5])
2839920	Beryllium ores and concentrates	--	53	--	--	--	--	--	--	47
2839930	Columbium ores and concentrates	32	39	1	6	4	--	14	--	3
2840200	Copper waste and scrap	87	5	1	--	5	--	--	--	2
2840300	Nickel waste and scrap	71	--	25	--	--	--	--	--	5
2840400	Aluminum waste and scrap	50	1	11	38	--	--	--	--	1
2840500	Magnesium waste and scrap	9	--	76	--	5	--	5	--	4
2840600	Lead waste and scrap	37	44	--	--	--	--	--	--	19
2840700	Zinc waste and scrap	80	--	19	--	--	--	--	--	1
2840900	Tin waste and scrap	12	--	82	--	--	--	--	--	6

Table 13.—Percentage distribution of imports of principal minerals and mineral fuels and related products in 1976, by area of origin —Continued

SITC code[1]	Commodity	North America[2]	South America	Europe, excluding centrally planned economies	Europe, centrally planned economies[3]	Asia, excluding centrally planned economies	Asia, centrally planned economies[4]	Africa	Oceania	Undistributed
2850140, 2850240	Platinum-group metal ores, concentrates, waste	43	5	44	--	--	--	2	6	([5])
2860000	Uranium thorium ores and concentrates	--	--	--	--	100	--	--	--	--
3214000, 3218000, 3219000	Coal, coke, briquets	9	1	77	6	([5])	--	7	--	([5])
3310000	Petroleum, crude and partly refined	14	7	1	([5])	41	--	37	--	([5])
3320000	Petroleum products, except chemicals	48	33	6	2	6	--	4	([5])	([5])
3410000	Gases, natural and manufactured	93	3	([5])	([5])	2	--	1	([5])	([5])
5132500	Mercury, including waste and scrap	9	1	40	15	--	8	26	--	1
5136500	Alumina	27	4	4	--	([5])	--	--	64	([5])
5210000	Mineral tar and crude chemicals from coal, petroleum and natural gas	13	--	85	--	1	--	--	--	1
5613000	Potassic fertilizers and fertilizer materials	96	([5])	2	1	1	--	([5])	--	([5])

[1]Standard International Trade Classification.
[2]Includes Trinidad and the Netherlands Antilles.
[3]The U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Romania, Yugoslavia, Estonia, Latvia, Lithuania.
[4]The People's Republic of China, North Korea, Vietnam, Laos, Cambodia, Mongolia.
[5]Less than 1/2 unit.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. General Imports, Schedule A. FT 135, December 1976, table 2, customs value.

Table 14.—Consumption of major mineral products, mineral fuels, and electricity, and projections

Commodity and unit	1975	1976	2000
MINERAL PRODUCTS			
Ferrous metals:			
Iron ore ---- thousand long tons--	114,126	125,424	NA
Iron content[e] ---- thousand short tons--	79,250	87,095	129,000
Raw steel (production) ---- do----	116,642	128,000	237,000
Chromite ores (gross weight):			
Metallurgical grade ---- do----	532	597	
Refractory grade ---- do----	183	202	1,200
Chemical grade ---- do----	166	207	
Manganese ore (35% or more Mn) ---- do----	1,819	1,601	3,900
Molybdenum (Mo content) ---- thousand pounds--	51,743	50,448	188,000
Tungsten (W content) ---- do----	14,012	16,107	76,400
Nonferrous metals:			
Aluminum (apparent consumption) ---- thousand short tons--	3,903	5,118	28,400
Antimony, primary ---- short tons--	12,987	15,337	48,000
Copper, refined ---- thousand short tons--	1,535	1,992	7,100
Lead, primary and secondary ---- do----	1,297	1,490	2,730
Mercury, primary ---- 76-pound flasks--	48,649	68,371	102,000
Platinum-group metals ---- thousand troy ounces--	1,309	1,603	3,157
Silver (industrial and the arts) ---- do----	157,650	170,559	420,000
Ilmenite and titanium slag (estimated TiO_2 content) - short tons--	536,994	642,519	1,840,000
Uranium (U_3O_8, estimated purchases by private industry) do----	12,500	14,000	73,113
Nonmetals:			
Asbestos (apparent consumption) ---- thousand short tons--	608	726	2,430
Cement (apparent consumption) ---- million short tons--	70	74	220
Clays (apparent consumption) ---- thousand short tons--	49,388	53,181	174,000
Lime (sold or used) ---- do----	19,133	20,229	43,300
Phosphate rock (P_2O_5 content, apparent consumption) -- do----	10,315	10,345	57,000
Potash (K_2O content, apparent consumption) ---- do----	5,112	6,149	14,455
Salt (apparent consumption) ---- do----	42,913	47,536	136,400
Sand and gravel ---- million short tons--	789	885	3,200
Stone, crushed (sold or used) ---- do----	901	900	3,400
Sulfur, all forms (apparent consumption) - thousand long tons--	10,603	10,768	30,000
MINERAL ENERGY RESOURCES AND ELECTRICITY			
Energy resources:			
Bituminous coal ---- million short tons--	556	597	1,000
Coal carbonized for coke[1] ---- do----	(83)	(84)	(115)
Anthracite ---- do----	5	5	2
Petroleum production and natural gas liquids - million barrels--	5,958	6,384	14,500
Natural gas, dry[2] ---- million cubic feet--	19,538	[e]19,813	49,000
Electricity generation, net ---- million kilowatt hours--	2,002,983	2,123,422	NA
Utilities ---- do----	1,917,619	2,036,503	[3]8,650,000
Hydropower[4] ---- do----	306,253	292,318	[3] [5]605,000
Nuclear power ---- do----	172,506	191,111	[3]5,085,000
Conventional fuel-burning plants ---- do----	1,445,048	1,561,685	[3]2,960,000
Industrial ---- do----	85,364	86,919	NA
Total energy resources inputs ---- trillion Btu--	70,576	74,025	[3]163,430

[e]Estimate. NA Not available.
[1]Figures in parentheses are not added to totals.
[2]Residual gas excludes extraction loss but includes transmission loss.
[3]Dupree, W. G., Jr., and J. S. Corsentino. U.S. Energy Through Year 2000 (revised). U.S. Bureau of Mines. December 1975, tables 1 and 15.
[4]Net generations adjusted for net imports or exports. The bulk of net trade is hydropower with an undetermined amount of steam plant power.
[5]Includes power produced at geothermal plants.

Table 15.—Energy equivalent in British thermal units (Btu) obtained from mineral energy resources produced and from hydroelectric and nuclear power produced

(Trillion Btu)

	1972	1973	1974	1975	1976[p]
Anthracite	181	174	168	158	158
Bituminous coal and lignite	14,319	14,208	14,319	15,044	15,610
Crude petroleum	20,041	19,493	18,575	17,729	17,262
Hydroelectric power	2,866	2,860	3,177	3,155	2,974
Natural gas	24,792	24,764	23,689	22,022	21,831
Nuclear power	576	888	1,211	1,832	2,037
Total	62,775	62,387	61,139	59,940	59,872

[p]Preliminary.

Table 16.—Energy consumed in British thermal units (Btu) as equivalent to consumption of mineral energy resources, and hydroelectric and nuclear power

(Trillion Btu)

	1972	1973	1974	1975	1976	Percent (1976)
Anthracite	150	144	138	130	128	1
Bituminous coal and lignite	12,273	13,150	12,751	12,684	13,443	18
Hydroelectric power	2,946	3,009	3,309	3,219	3,064	4
Natural gas	22,698	22,512	21,733	19,948	20,209	27
Natural gas liquids	2,584	2,576	2,479	2,382	2,350	3
Nuclear power	576	888	1,211	1,839	2,037	3
Petroleum products, except natural gas liquids	30,382	32,276	30,988	30,360	32,794	44
Total energy consumed	71,609	74,555	72,609	70,562	74,025	100

Table 17.—Consumption of energy resources, by consuming sector

(Trillion Btu)

Final consuming sector and resource	1972	1973	1974	1975	1976	Percent (1976)
Industrial:						
Natural gas	9,880	10,500	10,000	8,550	8,760	41
Petroleum	5,640	6,080	5,910	5,530	6,200	29
Bituminous coal	4,240	4,340	4,040	3,760	3,600	17
Utility electricity	2,490	2,640	2,670	2,580	2,810	13
Anthracite	35	33	35	35	42	--
Hydropower	35	38	33	32	33	--
Coke	--	--	59	14	--	--
Total	22,300	23,600	22,800	20,500	21,400	100
Transportation:						
Petroleum	17,300	18,200	17,700	17,900	18,900	97
Natural gas	787	744	685	595	534	3
Utility electricity	17	15	16	16	16	--
Bituminous coal	4	3	2	1	--	--
Total	18,100	19,000	18,400	18,600	19,500	100
Household and commercial:						
Natural gas	7,940	7,630	7,520	7,590	7,770	42
Petroleum	6,670	6,700	6,100	5,750	6,270	34
Utility electricity	3,480	3,720	3,730	3,970	4,150	23
Bituminous coal	233	222	232	188	171	1
Anthracite	75	74	66	57	51	--
Total	18,400	18,300	17,600	17,600	18,400	100
Electric utilities:						
Bituminous coal	7,800	8,580	8,480	8,730	9,680	67
Petroleum	3,130	3,660	3,480	3,230	3,450	24
Natural gas	4,090	3,680	3,510	3,210	3,140	22
Hydropower	2,910	2,970	3,280	3,190	3,030	21
Nuclear power	576	888	1,210	1,840	2,040	14
Anthracite	40	37	38	38	34	--
Utility electricity to other sectors	-5,990	-6,380	-6,410	-6,560	-6,980	-48
Total	12,600	13,400	13,600	13,700	14,400	100
Total consumption:						
Petroleum	33,000	34,900	33,500	32,700	35,100	47
Natural gas	22,700	22,500	21,700	19,900	20,200	27
Bituminous coal	12,300	13,200	12,800	12,700	13,400	18
Hydropower	2,950	3,010	3,310	3,220	3,060	4
Nuclear power	576	888	1,210	1,840	2,040	3
Anthracite	150	144	138	130	128	--
Coke	--	--	59	14	--	--
Total	71,600	74,600	72,700	70,600	74,000	100

Table 18.—Domestic supply and demand for coal

	1975		1976[p]	
	Thousand short tons	Trillion Btu	Thousand short tons	Trillion Btu
ANTHRACITE				
Supply:				
Production[1]	6,203	157.5	6,228	158.2
Exports[2]	-1,095	-27.8	-1,188	-30.2
Imports	--	--	--	--
Stock change: Withdrawals(+), additions(-)	NA	NA	NA	NA
Losses, gains, and unaccounted for	--	--	--	--
Total	5,108	129.7	5,040	128.0
Demand by major consuming sectors: [3]				
Household and commercial[4]	2,240	56.9	2,020	51.3
Industrial[5]	1,386	35.2	1,670	42.4
Electricity generation, utilities	1,482	37.6	1,350	34.3
Total	5,108	129.7	5,040	128.0
BITUMINOUS COAL AND LIGNITE				
Supply:				
Production[1]	648,438	15,043.8	678,685	15,609.8
Exports	-65,669	-1,773.0	-59,406	-1,604.0
Imports	940	21.4	1,203	27.0
Stock change: Withdrawals(+), additions(-)	-31,765	-687.7	-6,166	-133.9
Losses, gains, and unaccounted for	4,357	79.2	-16,837	-455.6
Total	556,301	12,683.7	597,479	13,443.3
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial[4]	7,282	188.1	6,900	171.3
Industrial[5]	142,072	3,669.8	141,179	3,505.1
Coal carbonized for coke[6]	(83,274)	(2,151.0)	(84,324)	(2,093.5)
Transportation[7]	24	.6	12	.3
Electricity generation, utilities	403,249	8,730.3	445,750	9,676.3
Total	552,627	12,588.8	593,841	13,353.0
Raw material: Industrial: [8]				
Crude light oil	974	25.2	990	24.6
Crude coal tar	2,700	69.7	2,648	65.7
Total	3,674	94.9	3,638	90.3
Grand total	556,301	12,683.7	597,479	13,443.3

[p]Preliminary. NA Not available.
[1]Includes use by producers for power and heat.
[2]Includes shipments to U.S. Armed Forces in West Germany.
[3]Except for small quantities used as raw material for coal chemicals, all anthracite is used for fuel and power.
[4]Data represent "retail deliveries to other consumers." These are mainly household and commercial users, with some unknown portion of use by small industries.
[5]Includes consumption by coke plants, steel and rolling mills, and other industrial uses. Adjusted to exclude coal equivalent of raw material uses.
[6]Figures in parentheses are not added into totals.
[7]Includes bunkers and military transportation.
[8]Coal equivalent based on British thermal unit value of raw material consumption of coal chemicals listed.

Table 19.—Natural gas, components of supply and demand

	1975		1976	
	Billion cubic feet	Trillion Btu	Billion cubic feet	Trillion Btu
Supply:				
Production	20,100	22,000	20,000	21,800
Exports	-73	-74	-65	-66
Imports	953	973	964	983
Stock change	-344	-351	77	79
Transfers out, offtake	-872	-2,380	-854	-2,350
Transmission loss, etc	-235	-240	-262	-267
Total supply	19,500	19,900	19,800	20,200
Demand:				
Industrial:				
For carbon black	26	27	28	29
For other chemicals	568	580	588	599
Fuel and power	7,780	7,940	7,970	8,130
Household and commercial	7,430	7,590	7,620	7,770
Electric utilities	3,150	3,210	3,080	3,140
Transportation, pipeline	583	595	524	534
Total demand	19,500	19,900	19,800	20,200

Table 20.—Domestic supply and demand for petroleum[1]

	1975		1976[p]	
	Million barrels	Trillion Btu	Million barrels	Trillion Btu
Supply:				
Crude oil:				
Production	3,056.8	17,729.3	2,976.2	17,261.8
Exports	-2.1	-12.2	-2.9	-16.8
Imports	1,498.2	8,689.6	1,935.1	11,223.6
Stock change: Withdrawals(+), additions(-)	-6.3	-36.5	-14.1	-81.8
Losses, transfers for use as fuel, and unaccounted for	-5.2	-30.1	15.9	92.4
Total	4,541.4	26,340.1	4,910.2	28,479.2
Refinery input:				
Crude oil	4,541.4	26,340.1	4,910.2	28,479.2
Transfers in, natural gas liquids[2]	259.3	1,172.2	265.5	1,198.7
Other hydrocarbons	13.8	48.3	13.9	48.7
Total	4,814.5	27,560.6	5,189.6	29,726.6
Refined products:				
Refinery output	4,814.5	27,560.6	5,189.6	29,726.6
Unfinished oil reruns, net	12.7	74.0	7.6	44.3
Processing gain, net	167.8	--	174.7	--
Total	4,995.0	27,634.6	5,371.9	29,770.9
Exports[3]	-74.3	-424.4	-78.7	-448.3
Imports[3]	712.2	4,229.2	734.8	4,389.1
Stock change, including natural gas liquids	-53.0	-256.5	+35.3	+200.6
Transfers in, natural gas liquids[2 4]	336.7	1,209.6	321.5	1,151.6
Losses, gains, and unaccounted for	40.9	349.1	-.7	79.7
Total	5,957.5	32,741.6	6,384.1	35,143.6
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	854.7	4,739.6	946.0	5,267.5
Industrial	616.3	3,585.8	692.5	4,041.0
Transportation[5]	3,309.8	17,789.4	3,477.3	18,706.8
Electricity generation, utilities	518.3	3,228.8	552.7	3,446.2
Other, not specified	16.4	98.4	10.9	63.9
Total	5,315.5	29,442.0	5,679.4	31,525.4
Raw material:[6]				
Petrochemical feedstock offtake	340.6	1,434.2	389.4	1,676.5
Other nonfuel use	268.7	1,685.7	267.7	1,679.7
Total	609.3	3,119.9	657.1	3,356.2
Miscellaneous and unaccounted for	32.7	179.7	47.6	262.0
Grand total	5,957.5	32,741.6	6,384.1	35,143.6

[p]Preliminary.
[1]Supply and demand for crude oil and petroleum products. Petroleum products include products refined and processed from crude oil, including still gas and liquefied refinery gas; also natural gas liquids transferred from natural gas.
[2]Btu values for natural gas liquids for each year shown are implicitly derived from weighted averages of major natural gas liquids, with natural gasoline and other products at 110,000 Btu per gallon, liquefied petroleum gases at 95,500 Btu per gallon, ethane at 73,390 Btu per gallon, and plant condensate at 129,000 Btu per gallon.
[3]Btu values for imported and exported refined products for each year shown are totals of the Btu values of the respective products imported and exported.
[4]Includes natural gas liquids other than those channeled into refinery input as follows: Petrochemical feedstocks, direct uses for fuel and power, and other uses.
[5]Includes bunkers and military fuel uses.
[6]Includes some fuel and power use by raw materials industries.

Table 21.—Petroleum consumption, by major product and major consuming sector[1]

	Household and commercial		Industrial		Transportation[2]		Electricity generation, utilities		Miscellaneous and unaccounted for		Total domestic product demand	
	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu
1975												
Fuel and power:												
Liquefied gases	167.1	670.2	[3]67.7	271.6	27.7	111.1	--	--	--	--	262.5	1,052.9
Jet fuels:												
Naphtha type	--	--	--	--	76.5	409.7	--	--	--	--	76.5	409.7
Kerosine type	--	--	[4]1.8	10.2	283.8	1,609.2	3.2	18.1	--	--	288.8	1,637.5
Total	--	--	[4]1.8	10.2	360.3	2,018.9	3.2	18.1	--	--	365.3	2,047.2
Gasoline	--	--	--	--	2,450.3	12,859.2	--	--	--	--	2,450.3	12,859.2
Kerosine	45.1	255.7	12.9	73.2	--	--	--	--	--	--	58.0	328.9
Distillate fuel	488.4	2,844.9	126.6	737.5	355.2	2,069.0	60.2	350.7	10.2	59.4	1,040.6	6,061.5
Residual fuel	154.1	968.8	167.1	1,050.5	116.3	731.2	454.9	2,860.0	6.2	39.0	898.6	5,649.5
Still gas	--	--	175.4	1,052.4	--	--	--	--	--	--	175.4	1,052.4
Petroleum coke	--	--	64.8	390.4	--	--	--	--	--	--	64.8	390.4
Total	854.7	4,739.6	616.3	3,585.8	3,309.8	17,789.4	518.3	3,228.8	16.4	98.4	5,315.5	29,442.0
Raw material:[5]												
Plant condensate	--	--	6.9	37.4	--	--	--	--	--	--	6.9	37.4
Special naphthas	--	--	27.5	144.3	--	--	--	--	--	--	27.5	144.3
Lubes[6] and waxes	--	--	30.1	179.3	26.2	158.9	--	--	--	--	56.3	338.2
Petroleum coke[7]	--	--	25.2	151.8	--	--	--	--	--	--	25.2	151.8
Asphalt and road oil	152.8	1,014.0	--	--	--	--	--	--	--	--	152.8	1,014.0
Petrochemical feedstock offtake:												
Liquefied refinery gas[8]	--	--	32.8	127.7	--	--	--	--	--	--	32.8	127.7
Liquefied petroleum gas[8 9]	--	--	191.1	654.8	--	--	--	--	--	--	191.1	654.8
Naphtha (-400°)	--	--	53.5	280.8	--	--	--	--	--	--	53.5	280.8
Still gas	--	--	15.7	94.2	--	--	--	--	--	--	15.7	94.2
Miscellaneous (+400°)	--	--	47.5	276.7	--	--	--	--	--	--	47.5	276.7
Total	152.8	1,014.0	430.3	1,947.0	26.2	158.9	--	--	--	--	609.3	3,119.9
Miscellaneous and unaccounted for	--	--	--	--	--	--	--	--	32.7	179.7	32.7	179.7
Grand total, domestic product demand	1,007.5	5,753.6	1,046.6	5,532.8	3,336.0	17,948.3	518.3	3,228.8	49.1	278.1	5,957.5	32,741.6

1976[P]												
Fuel and power:												
Liquefied gases	175.4	703.5	[3]73.0	292.8	29.0	116.4	--	--	--	--	277.4	1,112.7
Jet fuels:												
Naphtha type	--	--	--	--	72.7	389.3	--	--	--	--	72.7	389.3
Kerosine type	--	--	[4].7	4.0	283.7	1,608.6	4.2	23.8	--	--	288.6	1,636.4
Total	--	--	[4].7	4.0	356.4	1,997.9	4.2	23.8	--	--	361.3	2,025.7
Gasoline	--	--	--	--	2,567.2	13,472.7	--	--	--	--	2,567.2	13,472.7
Kerosine	47.4	268.8	14.5	82.2	--	--	--	--	--	--	61.9	351.0
Distillate fuel	544.3	3,170.5	147.4	858.6	387.3	2,256.0	56.3	327.9	10.3	60.1	1,145.6	6,673.1
Residual fuel	178.9	1,124.7	210.5	1,323.4	137.4	863.8	492.2	3,094.5	.6	3.8	1,019.6	6,410.2
Still gas	--	--	180.7	1,084.2	--	--	--	--	--	--	180.7	1,084.2
Petroleum coke	--	--	65.7	395.8	--	--	--	--	--	--	65.7	395.8
Total	946.0	5,267.5	692.5	4,041.0	3,477.3	18,706.8	552.7	3,446.2	10.9	63.9	5,679.4	31,525.4
Raw material:[5]												
Plant condensate	--	--	.9	5.0	--	--	--	--	--	--	.9	5.0
Special naphthas	--	--	30.1	158.0	--	--	--	--	--	--	30.1	158.0
Lubes[6] and waxes	--	--	29.1	176.5	33.8	201.2	--	--	--	--	62.9	377.7
Petroleum coke[7]	--	--	23.4	140.9	--	--	--	--	--	--	23.4	140.9
Asphalt and road oil	150.4	998.1	--	--	--	--	--	--	--	--	150.4	998.1
Petrochemical feedstock offtake:												
Liquefied refinery gas[8]	--	--	40.4	156.5	--	--	--	--	--	--	40.4	156.5
Liquefied petroleum gas[8 9]	--	--	196.2	669.2	--	--	--	--	--	--	196.2	669.2
Naphtha (-400°)	--	--	73.3	384.7	--	--	--	--	--	--	73.3	384.7
Still gas	--	--	17.4	104.4	--	--	--	--	--	--	17.4	104.4
Miscellaneous (+400°)	--	--	62.1	361.7	--	--	--	--	--	--	62.1	361.7
Total	150.4	998.1	472.9	2,156.9	33.8	201.2	--	--	--	--	657.1	3,356.2
Miscellaneous and unaccounted for	--	--	--	--	--	--	--	--	47.6	262.0	47.6	262.0
Grand total, domestic product demand	1,096.4	6,265.6	1,165.4	6,197.9	3,511.1	18,908.0	552.7	3,446.2	58.5	325.9	6,384.1	35,143.6

[P]Preliminary.
[1]Includes liquefied refinery gas and natural gas liquids.
[2]Includes bunkers, military transportation, and all military use of distillate and residual fuel oils.
[3]Includes secondary recovery of petroleum and agriculture uses.
[4]Kerosine-type jet fuel sold for use as kerosine totaled 1,763,000 barrels in 1975 and 651,000 barrels in 1976.
[5]Includes some fuel and power used by raw materials industries.
[6]Lubricants are distributed on basis of data from Bureau of the Census.
[7]Includes portions of petroleum coke estimated to be consumed in nonfuel uses.
[8]Includes ethane.
[9]Includes liquefied petroleum gas for synthetic rubber.

Table 22.—Electrical energy sales to ultimate consumers

(Million kilowatt hours)

Region	Total consumption	Residential	Industrial and commercial	Total consumption	Residential	Industrial and commercial
	1972			1973		
New England	63,782	24,614	37,509	68,364	26,169	40,461
Middle Atlantic	219,861	65,978	140,639	235,310	70,729	153,006
East North-Central	304,297	89,736	203,268	331,776	96,164	223,580
West North-Central	100,687	39,074	58,316	108,912	42,146	63,212
South Atlantic	252,811	93,563	149,062	280,103	106,750	163,548
East South-Central	153,430	48,404	102,441	168,890	51,958	114,161
West South-Central	181,902	57,952	116,218	195,624	62,205	125,314
Mountain	71,805	20,609	47,719	77,181	23,375	50,294
Pacific	223,309	69,441	142,551	230,547	72,354	146,584
Alaska and Hawaii	5,830	2,052	3,603	6,496	2,321	3,978
Total United States	1,577,714	511,423	1,001,326	1,703,203	554,171	1,084,138
	1974			1975		
New England	66,894	26,094	39,180	66,887	26,309	38,958
Middle Atlantic	229,430	68,820	149,177	227,080	71,007	144,495
East North-Central	328,968	96,949	219,985	330,818	102,914	215,005
West North-Central	109,670	42,339	63,725	115,923	46,212	66,018
South Atlantic	279,090	106,656	163,518	286,302	112,179	164,540
East South-Central	169,246	51,610	114,818	172,602	54,386	115,257
West South-Central	200,735	63,239	129,405	207,154	68,017	130,877
Mountain	81,670	24,464	53,536	84,026	25,979	54,309
Pacific	228,243	72,390	144,603	235,073	76,640	145,662
Alaska and Hawaii	6,823	2,399	4,204	7,159	2,506	4,506
Total United States	1,700,769	554,960	1,082,151	1,733,024	586,149	1,079,627

Source: Edison Electric Institute. Statistical Yearbook of the Electric Utility Industry, 1972-75, table 22S.

Table 23.—Total employment in selected mineral industries

(Thousands)

Industry	1972	1973	1974	1975	1976
MINING					
Metals:					
Iron ores	20.1	21.3	24.2	24.8	25.4
Copper ores	38.9	42.3	42.8	37.1	35.5
Total[1]	86.1	90.5	92.3	92.3	93.1
Nonmetal mining and quarrying	112.1	115.8	119.2	115.1	115.1
Fuels:					
Bituminous coal	143.2	158.0	165.0	198.2	210.4
Other coal	3.7	3.6	3.5	3.6	3.9
Crude petroleum and natural gas fields	137.8	133.5	143.7	159.5	165.0
Oil and gas field services	124.1	131.0	148.2	176.2	195.3
Total	408.8	426.1	460.4	537.5	574.6
Total mining[2]	607.0	625.0	672.0	745.0	783.0
MANUFACTURING					
Minerals:					
Fertilizers, complete and mixing only	35.8	38.5	37.3	33.7	33.5
Cement, hydraulic	33.6	33.8	32.7	30.3	29.6
Blast furnaces, steelworks, rolling mills	492.2	521.8	522.6	470.1	469.9
Nonferrous smelting and refining	83.6	86.3	90.7	82.2	84.3
Total	645.2	680.4	683.3	[2]616.3	617.3
Fuels:					
Petroleum refining	150.8	147.3	154.6	154.2	157.1
Other petroleum and coal products	38.8	40.0	40.7	43.2	45.8
Total[2 3]	189.6	187.3	195.3	197.4	202.8
Total selected manufacturing	834.8	867.7	878.6	813.7	820.1

[1]Includes other metal mining not shown separately.
[2]Data may not add to totals shown because of independent rounding.
[3]Standard Industrial Classification 295, paving and roofing materials, included in total.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings. V. 19-22, No. 9, March 1973-1976, table B-2; v. 24, No. 3, March 1977, table B-2.

Table 24.—Average hours and gross earnings of production and related workers in the mineral and mineral fuels industries

	1972	1973	1974	1975	1976
MINING					
Metal mining:					
Iron ores:					
Weekly earnings	$185.40	$198.56	$241.43	$271.35	$303.73
Weekly hours	41.2	42.7	43.5	42.8	42.9
Hourly earnings	$4.50	$4.65	$5.55	$6.34	$7.08
Copper ores:					
Weekly earnings	$192.19	$206.52	$226.46	$248.14	$280.70
Weekly hours	41.6	42.3	41.1	39.2	40.1
Hourly earnings	$4.62	$4.88	$5.51	$6.33	$7.00
All metal mining:[1]					
Weekly earnings	$185.51	$200.40	$226.97	$250.72	$280.80
Weekly hours	41.5	42.1	41.8	40.9	41.6
Hourly earnings	$4.47	$4.76	$5.43	$6.13	$6.75
Nonmetallic mining and quarrying:					
Weekly earnings	$176.96	$196.88	$209.28	$210.98	$236.72
Weekly hours	44.8	47.1	46.3	43.5	44.0
Hourly earnings	$3.95	$4.18	$4.52	$4.85	$5.38
All mining (excluding fuels):[2]					
Weekly earnings	$180.61	$195.90	$213.09	$228.55	$256.16
Weekly hours	43.4	44.0	43.5	42.4	42.9
Hourly earnings	$4.17	$4.47	$4.91	$5.42	$5.99
Fuels:					
All coal mining:					
Weekly earnings	$215.83	$226.86	$236.84	$283.35	$312.44
Weekly hours	[3]41.0	39.9	38.2	[3]39.3	[3]39.5
Hourly earnings	[3]$5.30	[3]$5.69	$6.20	[3]$7.21	[3]$7.88
Bituminous coal:					
Weekly earnings	$217.46	$228.45	$238.37	$284.53	$313.24
Weekly hours	[3]41.0	39.8	38.2	[3]39.2	[3]39.5
Hourly earnings	[3]$5.34	[3]$5.74	$6.24	[3]$7.23	[3]$7.91
Crude petroleum and natural gas:					
Weekly earnings	$169.92	$191.82	$223.86	$248.84	$272.83
Weekly hours	42.8	40.9	42.0	40.8	41.4
Hourly earnings	$3.97	$4.69	$5.33	$6.05	$6.59
All fuels:[2]					
Weekly earnings	$191.27	$201.43	$224.08	$256.86	$282.16
Weekly hours	41.8	40.8	41.9	42.2	42.7
Hourly earnings	$4.53	$4.90	$5.39	$6.14	$6.66
MANUFACTURING					
Fertilizers, complete and mixing only:					
Weekly earnings	$143.14	$155.66	$172.40	$188.72	$210.33
Weekly hours	42.6	43.0	43.1	42.6	43.1
Hourly earnings	$3.36	$3.62	$4.00	$4.43	$4.88
Cement, hydraulic:					
Weekly earnings	$215.37	$233.20	$247.97	$262.06	$302.74
Weekly hours	42.0	42.4	42.1	41.4	41.7
Hourly earnings	$5.12	$5.50	$5.89	$6.33	$7.26
Blast furnaces, steel and rolling mills:					
Weekly earnings	$210.12	$230.74	$263.49	$278.71	$312.38
Weekly hours	40.8	41.8	41.3	39.2	39.8
Hourly earnings	$5.15	$5.56	$6.38	$7.11	$7.86
Nonferrous smelting and refining:					
Weekly earnings	$185.59	$203.46	$227.46	$243.76	$275.22
Weekly hours	41.8	42.3	42.2	40.9	41.7
Hourly earnings	$4.44	$4.81	$5.39	$5.96	$6.60
Petroleum refining and related industries:					
Weekly earnings	$208.89	$220.28	$238.71	$267.07	$301.31
Weekly hours	42.2	42.2	42.4	41.6	42.2
Hourly earnings	$4.95	$5.22	$5.63	$6.42	$7.14
Petroleum refining:					
Weekly earnings	$219.45	$231.02	$250.92	$283.87	$324.73
Weekly hours	41.8	41.7	42.1	41.2	41.9
Hourly earnings	$5.25	$5.54	$5.96	$6.89	$7.75
Other petroleum and coal products:					
Weekly earnings	$175.34	$187.91	$199.67	$215.28	$231.66
Weekly hours	43.4	43.7	43.5	42.8	42.9
Hourly earnings	$4.04	$4.30	$4.59	$5.03	$5.40
Total selected manufacturing:[2]					
Weekly earnings	$206.52	$224.92	$250.99	$268.58	$292.76
Weekly hours	41.1	41.7	41.7	40.1	39.5
Hourly earnings	$5.02	$5.41	$6.08	$6.71	$7.21

[1]Includes other metal mining not shown.
[2]Weighted average of data computed using figures for production workers as weights.
[3]11-month average.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings. V. 19-22, No. 9, March 1973-1976, table C-2; v. 24, No. 3, March 1977, table B-2, C-2.

Table 25.—Wages, salaries, and average annual earnings in the United States

	1974[r]	1975[r]	1976	Percent change 1974-75	Percent change 1975-76
Wages and salaries:					
All industries, total ____ millions__	$764,054	$805,705	$891,828	+5.5	+10.7
Mining ____ do____	8,827	10,826	12,179	+22.6	+12.5
Manufacturing ____ do____	211,388	211,039	238,170	-.2	+12.9
Average earnings per full-time employee:					
All industries, total ____	9,991	10,845	11,623	+8.5	+7.2
Mining ____	12,905	14,769	16,089	+14.4	+8.9
Manufacturing ____	10,847	11,905	12,888	+9.8	+8.3

[r]Revised.

Source: U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. V. 57, No. 7, July 1977, p. 46, table 6.6; p. 47, table 6.9.

Table 26.—Average labor-turnover rates in selected mineral industries[1]

(Per thousand employees)

Rate and year	Manufacturing	Cement, hydraulic	Blast furnaces, steel and rolling mills	Nonferrous smelting and refining	Metal mining	Iron ores	Copper ores	Petroleum refining and related industries[2]	Petroleum refining	Coal mining
Total accession rate:										
1974 ____	42	15	20	27	35	26	32	23	17	19
1975 ____	37	29	28	18	27	23	19	18	12	23
1976 ____	39	30	32	26	32	27	32	20	14	20
Total separation rate:										
1974 ____	48	22	23	26	31	21	31	24	15	13
1975 ____	42	41	42	30	32	27	31	19	12	14
1976 ____	38	28	31	22	30	26	28	20	14	18
Layoff rate:										
1974 ____	15	10	7	4	3	4	3	7	4	2
1975 ____	21	31	30	17	10	13	13	7	3	2
1976 ____	13	17	19	5	8	10	11	7	5	3

[1]Monthly rates are available in Employment and Earnings as indicated in source.
[2]Standard Industrial Classification 295, paving and roofing materials, included in total.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings. V. 21-22, No. 9, March 1975-76, table D-2; v. 24, No. 3, March 1977, table D-2.

Table 27.—Labor productivity indexes for selected minerals[1]

(1967=100)

Year	Copper, crude ore mined per— Employee	Copper, crude ore mined per— Production worker	Copper, crude ore mined per— Production worker man-hour	Iron, crude ore mined per— Employee	Iron, crude ore mined per— Production worker	Iron, crude ore mined per— Production worker man-hour
1971	126.7	125.3	121.2	110.8	112.8	117.1
1972	123.7	119.3	118.1	119.2	122.2	124.4
1973	126.8	121.0	117.7	127.3	129.0	126.7
1974	121.4	117.3	117.6	120.8	122.4	118.1
1975[p]	123.7	122.9	128.9	116.8	119.0	116.6

Year	Copper, recoverable metal mined per— Employee	Copper, recoverable metal mined per— Production worker	Copper, recoverable metal mined per— Production worker man-hour	Iron, usable ore mined per— Employee	Iron, usable ore mined per— Production worker	Iron, usable ore mined per— Production worker man-hour
1971	109.7	108.4	104.9	97.5	99.3	103.0
1972	107.4	103.6	102.5	101.9	104.6	106.5
1973	104.6	99.7	97.0	108.7	110.1	108.2
1974	91.9	88.8	89.0	99.9	101.2	97.6
1975[p]	92.3	91.8	96.3	92.4	94.2	92.2

Year	Petroleum refined per— Employee	Petroleum refined per— Production worker	Petroleum refined per— Production worker man-hour	Bituminous coal and lignite mined per— Employee	Bituminous coal and lignite mined per— Production worker	Bituminous coal and lignite mined per— Production worker man-hour
1971	110.2	112.1	112.3	[1]87.2	[r]91.7	[r]91.5
1972	121.2	121.5	121.9	[r]82.8	[r]84.8	83.9
1973	131.4	133.0	135.7	[r]81.2	[r]82.3	[r]83.4
1974	121.8	121.3	121.8	76.0	77.5	82.1
1975[p]	120.6	120.0	123.2	70.2	71.5	73.7

[p]Preliminary. [r]Revised.
[1]Series revised to incorporate additional data from economic censuses.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Productivity Indexes for Selected Industries, 1976 edition, tables 2, 4, 6, 8, 12, 46.

Table 28.—Index of average unit mine value of minerals produced

(1967=100)

	1972	1973	1974	1975	1976[p]
METALS					
Ferrous	120.2	125.5	159.5	207.3	235.6
Nonferrous:					
Base	130.7	151.1	205.7	181.5	191.5
Monetary	138.1	222.3	380.2	373.5	319.4
Other	131.2	136.7	150.1	211.6	245.4
Average	131.5	155.5	212.8	205.8	213.8
Average, all metals	125.5	139.6	184.6	206.6	225.3
NONMETALS					
Construction	120.8	127.2	147.2	170.6	184.9
Chemical	85.2	91.1	128.5	204.1	196.9
Other	123.4	132.5	148.7	172.2	192.7
Average	113.0	119.4	143.1	178.2	188.0
FUELS					
Coal	165.2	183.3	339.8	403.5	420.6
Crude oil and natural gas	116.4	133.8	221.6	263.9	299.1
Average	123.4	141.6	241.4	282.9	315.5
Average, all minerals	121.2	136.4	214.6	253.1	279.4

[p]Preliminary.

Table 29.—Index of implicit unit value of minerals produced

(1967=100)

	1972	1973	1974	1975	1976[p]
METALS					
Ferrous	119.5	123.7	157.5	204.2	232.2
Nonferrous:					
Base	130.6	151.0	202.4	176.9	187.6
Monetary	136.2	212.2	369.4	356.5	312.2
Other	136.4	141.3	156.3	225.1	257.8
Average	131.4	153.3	205.8	192.3	202.3
Average, all metals	127.3	142.1	187.8	196.6	212.8
NONMETALS					
Construction	120.6	127.0	146.5	169.9	184.3
Chemical	84.6	90.2	126.6	204.6	196.5
Other	119.8	128.0	145.0	169.5	190.7
Average	112.5	119.2	141.8	178.3	187.6
FUELS					
Coal	165.5	183.5	340.2	403.4	420.4
Crude oil and natural gas	116.4	133.8	220.2	264.5	301.8
Average	129.2	141.5	240.8	286.1	321.3
Average, all minerals	121.2	136.4	211.5	252.7	278.2

[p]Preliminary.

Table 30.—Price indexes for selected metals, minerals, and fuels

(1967=100)

Commodity	Annual average 1975	Annual average 1976	Percent change from 1975
Metals and metal products	185.6	195.9	+5.5
Iron and steel	200.9	215.9	+7.5
Iron ore	154.3	171.0	+10.8
Iron and steel scrap	245.6	259.0	+5.5
Semifinished steel products	206.7	223.1	+7.9
Finished steel products	196.6	209.0	+6.3
Foundry and forge shop products	194.3	218.6	+12.5
Pig iron and ferroalloys	264.7	261.6	-1.2
Nonferrous metals	171.6	181.6	+5.8
Primary metal refinery shapes	[1]184.8	191.7	+3.7
Aluminum, primary, buyers	160.4	177.4	+10.6
Lead, pig, common	154.0	163.8	+6.4
Zinc, slab, prime western	270.2	260.9	-3.4
Nonferrous scrap	128.3	155.4	+21.1
Nonmetallic mineral products	174.0	186.3	+7.0
Concrete ingredients	172.3	186.7	+8.4
Sand, gravel, crushed stone	151.1	161.2	+6.7
Structural clay products, excluding refractories	151.2	163.5	+8.1
Gypsum products	144.0	154.4	+7.2
Other nonmetallic minerals	220.3	232.5	+5.5
Building lime	186.0	205.1	+10.3
Insulation materials	196.2	212.6	+8.4
Bituminous paving materials	256.9	265.1	+3.2
Fertilizer materials	198.8	163.6	-17.7
Nitrogenates	178.6	151.1	-15.4
Phosphates	236.3	187.8	-20.5
Phosphate rock	428.9	375.4	-12.5
Potash	166.6	167.3	+.4
Fuels and related products and power	245.1	265.6	+8.4
Coal	385.8	368.7	-4.4
Anthracite	372.7	385.3	+3.4
Bituminous	387.0	367.5	-5.0
Coke	330.8	346.8	+4.8
Gas fuels	216.7	286.8	+32.3
Electric power	193.4	207.6	+7.3
Petroleum products, refined	257.5	276.6	+7.4
Crude petroleum[2]	245.7	253.6	+3.2
All commodities other than farm and food	171.5	182.4	+6.4
All commodities	174.9	183.0	+4.6

[1]Corrected figure.
[2]Includes only domestic production.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes. January 1976, table 4; Supplement 1977, table 4.

Table 31.—Comparative mineral energy resource prices

Fuel	1974	1975	1976
Bituminous coal, average price at merchant coke ovens dollars per net ton	34.20	52.63	[p]54.90
Anthracite, average sales realization per net ton at preparation plants, excluding dredge coal:			
Chestnut dollars	31.06	45.34	[e]47.13
Pea do	27.61	42.33	[e]42.02
Buckwheat, No. 1 do	[r]18.88	27.61	29.11
Petroleum and petroleum products:			
Crude petroleum, average price per barrel at well do	6.74	[r]7.56	8.14
Gasoline, average dealers' net price (excluding taxes) of gasoline in 55 U.S. cities[1] cents per gallon	30.53	35.78	38.99
Residual fuel oil:[1]			
No. 6 fuel, maximum 1% sulfur, average of high and low prices at Philadelphia[2] dollars per barrel	11.95	12.26	12.05
No. 6 fuel, maximum 0.3% sulfur, average of high and low prices at Philadelphia[2] do	13.11	13.16	13.28
Bunker C, average of high and low prices at all gulf ports do	10.28	9.30	9.03
Distillate fuel oil:[1]			
No. 2 distillate, average of high and low prices at Philadelphia cents per gallon	25.26	29.19	31.52
No. 2 distillate, average of high and low prices at all gulf ports do	30.69	28.43	29.88
Natural gas:			
Average U.S. value at well cents per thousand cubic feet	30.4	44.5	58.0
Average U.S. value at point of consumption do	88.8	[e]115.0	NA

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Petroleum products from Platt's Oil Price Handbook.
[2]Prices at refineries and terminals in cargoes.

Table 32.—Cost of fuel in steam-electrical power generation

(Cents per million Btu)

Region	1973			1974			1975		
	Coal	Oil	Gas	Coal	Oil	Gas	Coal	Oil	Gas
New England	52.1	72.8	52.5	110.1	190.3	146.4	126.8	194.7	126.7
Middle Atlantic	47.4	80.0	62.4	81.2	200.1	114.1	102.1	199.3	90.6
East North-Central	42.9	78.4	58.2	65.4	170.0	76.8	82.1	194.4	110.9
West North-Central	36.9	81.6	34.6	44.1	139.0	41.8	59.8	175.7	56.0
South Atlantic	45.6	62.9	45.1	87.4	168.6	59.7	99.6	185.2	72.2
East South-Central	36.3	94.7	38.5	52.6	182.8	51.4	80.3	175.1	94.1
West South-Central	13.1	89.0	28.2	17.1	181.7	43.1	22.7	185.2	71.5
Mountain	25.1	95.9	39.1	28.7	164.0	50.8	31.8	211.2	73.1
Pacific	31.8	88.1	41.9	41.1	170.2	58.0	56.5	249.8	104.1
United States	41.4	75.9	34.1	66.2	181.1	48.3	81.5	202.0	75.2

Source: National Coal Association. Steam-Electric Plant Factors, 1974 through 1976, table 2.

Table 33.—Cost of electrical energy

(Cents per kilowatt-hour)

Region	1973			1974			1975		
	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial
New England	2.6	3.1	2.3	3.6	4.2	3.3	4.1	4.5	3.8
Middle Atlantic	2.5	3.2	2.2	3.4	4.2	3.0	3.9	4.6	3.5
East North-Central	1.9	2.6	1.6	2.3	2.9	2.0	2.7	3.3	2.4
West North-Central	2.1	2.5	1.8	2.3	2.6	2.0	2.7	3.0	2.4
South Atlantic	1.9	2.2	1.6	2.4	2.7	2.2	2.9	3.3	2.7
East South-Central	1.3	1.7	1.1	1.5	1.9	1.3	1.9	2.3	1.7
West South-Central	1.6	2.2	1.3	1.8	2.4	1.5	2.1	2.7	1.8
Mountain	1.7	2.2	1.5	1.8	2.4	1.6	2.2	2.8	2.0
Pacific	1.5	1.9	1.3	1.8	2.3	1.7	2.1	2.5	1.9
Alaska and Hawaii	2.7	3.1	2.5	2.9	4.2	2.6	3.8	4.1	3.6
United States	1.9	2.4	1.6	2.3	2.8	2.0	2.7	3.2	2.4

Source: Edison Electric Institute. Statistical Yearbook of the Electric Utilities Industry, 1973 through 1975. Based on tables 22-S and 36-S.

Table 34.—Price index of principal metal mining expenses[1]

(1967=100)

Year	Total	Labor	Supplies	Fuel	Electrical energy
1972	r123	r126	120	119	122
1973	r133	r135	128	146	129
1974	r168	r172	157	208	163
1975	189	190	177	245	193
1976	p199	p198	188	266	208

pPreliminary. rRevised.

[1]Indexes constructed using the following weights derived from the 1967 Census of Mineral Industries: Labor, 50.04; explosives, 3.18; steel mill shapes and forms, 7.32; all other supplies, 26.89; fuels, 5.88; electric energy, 6.69; and data from U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Prices and Price Indexes. The index is computed for iron and copper ores only because sufficient data are not available for other mining sectors.

Table 35.—Index of major input expenses for bituminous coal and crude petroleum and natural gas mining[1]

(1967=100)

Year	Bituminous coal	Crude petroleum and natural gas
1972	141	122
1973	155	136
1974	175	167
1975	222	NA
1976p	248	NA

pPreliminary. NA Not available.

[1]Indexes constructed by using data from the U.S. Department of Labor Statistics, Wholesale Prices and Price Indexes, annual and monthly and weights derived from data shown in the 1967 Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census. Weights used are as follows: Bituminous coal—labor, 61.55; explosives, 2.70; steel mill shapes and forms, 5.08; all other supplies, 24.58; fuels, 1.74; electric energy, 4.35; crude petroleum and natural gas—labor, 44.65; supplies, 48.79; fuel, 2.07; and electric energy, 4.49.

Table 36.—Indexes of relative costs and productivity for iron ore, copper, bituminous coal, and petroleum mining[1]

(1967=100)

Year	Iron ore[2]	Copper[2]	Bituminous coal	Petroleum
INDEX OF LABOR COSTS PER UNIT OF OUTPUT				
1972	r115	138	154	127
1973	r118	154	167	140
1974	r155	190	181	171
1975	180	202	244	NA
1976p	205	190	280	NA
INDEX OF VALUE OF PRODUCT PER PRODUCTION-WORKER-PERIOD				
1972	r126	136	153	129
1973	r134	150	169	143
1974	r143	178	313	226
1975	177	160	321	NA
1976p	193	204	317	NA
INDEX OF LABOR COSTS PER DOLLAR OF PRODUCT				
1972	r109	104	93	109
1973	r105	100	90	105
1974	r118	95	53	74
1975	109	121	60	NA
1976p	111	105	66	NA

pPreliminary. rRevised. NA Not available.

[1]Index of labor costs per unit of output: Iron ore and copper indexes are computed from data found in U.S. Department of Labor, Employment and Earnings and Wholesale Price Indexes. Bituminous coal index based upon net tons per man per day (see chapter on Bituminous Coal) and index of average earnings derived from Bureau of Labor Statistics data on hourly earnings; petroleum index based on barrels per year (see chapter on Petroleum) and Bureau of Employment Security data on total wages in petroleum production.

Index of value of product per production-worker period: Iron ore and copper indexes are computed from data found in U.S. Department of Labor, Employment and Earnings and Wholesale Price Indexes. Bituminous coal index based on net tons per man per day and mine value of production; petroleum index based on average employment and total value of production.

Index of labor costs per dollar of product: Iron ore and copper indexes are computed from data found in U.S. Department of Labor, Employment and Earnings and Wholesale Price Indexes. Bituminous coal index based on index of value per man per day and index of average earnings; petroleum index based on total value of production and total wages.

[2]Indexes are for recoverable metal.

Table 37.—Price indexes for selected cost items in minerals and mineral fuels production

(1967=100)

Commodity	1976		Percent change from January	Annual average		Percent change from 1975
	January	December		1975	1976	
Coal	370.3	373.9	+1.0	385.8	368.8	-4.4
Coke	331.1	363.4	+9.8	330.8	346.8	+4.8
Gas fuels	244.0	337.6	+38.4	216.7	286.8	+32.3
Petroleum products, refined	273.1	287.1	+5.1	257.5	276.4	+7.3
Industrial chemicals	212.6	221.9	+4.4	206.9	219.0	+5.8
Lumber	210.1	252.0	+19.9	192.5	233.0	+21.0
Explosives	188.8	186.9	-1.0	178.0	187.2	+5.2
Construction machinery and equipment	193.3	204.5	+5.8	185.2	198.6	+7.2

Source: U.S. Department of Labor. Bureau of Labor Statistics. Wholesale Prices and Price Indexes. January-December 1976, table 6; January 1977, table 4 and 6; Supplement 1976, table 5.

Table 38.—Price indexes for mining construction and material handling machinery and equipment

(1967=100)

Year	Construction machinery and equipment	Mining machinery and equipment	Oilfield machinery and tools	Power cranes, excavators, equipment	Specialized construction machinery	Portable air compressors	Scrapers and graders	Mixers, pavers, spreaders, etc.	Tractors other than farm
1972	125.7	117.2	127.3	126.0	129.0	92.0	124.4	126.3	127.3
1973	130.7	121.1	133.2	130.5	134.1	93.5	136.1	130.4	131.5
1974	152.3	143.6	157.8	152.2	151.3	102.8	160.4	145.1	154.7
1975	185.2	184.3	196.3	184.3	189.4	116.3	195.6	r161.0	188.3
1976	198.6	211.7	217.6	200.6	204.9	118.6	210.5	168.8	202.6

rRevised.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes. January-December 1975-76, table 6; supplement 1973, 1974, 1975, table 5.

Table 39.—National income originated in the mineral industries

Industry	Income (million dollars)			Percent change from 1975
	1974r	1975r	1976	
Mining	15,539	17,979	19,384	+7.8
Metal mining	1,596	1,637	1,755	+7.2
Coal mining	5,208	6,352	6,567	+3.4
Oil and gas extraction	6,661	7,762	8,765	+12.9
Nonmetallic minerals, except fuels	2,074	2,228	2,297	+3.1
Manufacturing	297,833	311,530	364,994	+17.2
Chemical and allied products	21,268	23,843	27,080	+13.6
Petroleum and coal products	13,977	12,424	15,531	+25.0
Stone, clay, and glass products	9,690	9,872	11,799	+19.5
Primary metal industries	26,631	24,523	26,584	+8.4
All industries	1,152,083	1,246,713	1,399,254	+12.2

rRevised.

Source: U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. V. 56, No. 7, July 1977, p. 45, table 6.3.

Table 40.—Annual average profit rates on shareholders' equity, after taxes, and total dividends, selected mineral manufacturing corporations

Industry	Annual profit rate (percent)			Total dividends (million dollars)		
	1975	1976[1]	Percent change from 1975	1975	1976[1]	Percent change from 1975
All manufacturing	11.6	14.0	+20.7	19,968	22,716	+13.8
Primary metals	r8.6	8.3	-3.5	1,188	1,200	+1.0
Iron and steel	r10.9	9.0	-17.4	746	773	+3.6
Nonferrous metals	r5.0	6.8	+36.0	442	425	-3.8
Stone, clay, glass products	r8.3	11.9	+43.4	413	440	+6.5
Chemicals and allied products	15.2	15.5	+2.0	2,768	3,128	+13.0
Petroleum and coal products	12.5	14.4	+15.2	4,245	4,414	+4.0

rRevised.

[1]During the first quarter of 1976 a considerable number of companies were reclassified by industry. To provide comparability, 1975 data has been revised to reflect these reclassifications.

Source: Federal Trade Commission. Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations. 1st and 4th Quarters 1976, tables 4, A-1, B-1, C-1, D-1.

Table 41.—Industrial and commercial failures and liabilities in mining and manufacturing

Industry	1974	1975	1976
Mining:[1]			
Number of failures	9	26	37
Current liabilities ... thousands	$10,102	$9,465	$105,962
Manufacturing:			
Number of failures	1,548	1,619	1,323
Current liabilities ... thousands	$823,722	$1,011,144	$1,015,760
All industrial and commercial industries:			
Number of failures	9,915	11,432	9,628
Current liabilities ... thousands	$3,053,137	$4,380,170	$3,011,271

[1]Including fuels.

Source: Dun and Bradstreet, Inc., Business Economics Division. Monthly Failure Report. K-17, No. 12, Mar. 5, 1976; K-18, No. 12, Mar. 26, 1977.

Table 42.—Expenditures for new plant and equipment by firms in mining and selected mineral manufacturing industries

(Billion dollars)

Industry	1974	1975	1976
Mining[1]	3.18	3.79	4.00
Manufacturing:			
Primary iron and steel	2.12	[2]3.71	3.81
Primary nonferrous metals	2.33	2.28	2.16
Stone, clay, glass products	1.44	1.42	1.72
Chemicals and allied products	5.69	6.25	6.68
Petroleum	8.00	10.51	11.62
All manufacturing	46.01	47.95	52.48

[1]Including fuels.
[2]Corrected figure.

Source: U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. V. 56, No. 3, March 1976, p. 19, table 7; v. 57, No. 3, March 1977, p. 31, table 7.

Table 43.—Plant and equipment expenditures of foreign affiliates of U.S. companies, by area and industry

(Million dollars)

Area or country	1974[r]			1975[r]			1976		
	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing
Canada	427	1,295	2,677	534	1,346	2,094	490	1,416	2,165
Latin America	270	933	1,217	317	720	1,356	192	606	1,615
Europe	9	1,985	6,374	6	3,016	6,500	13	3,313	6,547
All other areas	374	4,034	1,358	316	4,410	1,292	221	4,422	1,140
Total	1,080	8,247	11,626	1,173	9,492	11,242	916	9,757	11,467

[r]Revised.

Source: U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. V. 56, No. 9, September 1976, pp. 24-26.

Table 44.—Estimated gross proceeds from primary security offerings in 1976[1]

Type of security	Total corporate: Million dollars	Total corporate: Percent	Manufacturing: Million dollars	Manufacturing: Percent	Extractive[2]: Million dollars	Extractive[2]: Percent
Bonds	41,069	78.7	13,243	85.6	1,023	57.8
Preferred stock	2,789	5.4	344	2.2	140	7.9
Common stock	8,305	15.9	1,893	12.2	606	34.3
Total[3]	52,161	100.0	15,479	100.0	1,771	100.0

[1]Substantially all new issues of securities offered for cash sale in the United States in amounts over $100,000 and with terms of maturity of more than 1 year are covered in these data.
[2]Including fuels.
[3]Data may not add to totals shown because of independent rounding.

Source: U.S. Securities and Exchange Commission. Statistical Bulletin. V. 36, No. 4, April 1977, pp. 19-20.

Table 45.—Direct private investment of U.S. companies in foreign petroleum industries in 1975[p]

(Million dollars; net inflows to the United States designated by -)

Area or country	Petroleum: Book value beginning of year	Petroleum: Net capital outflows	Petroleum: Undistributed earnings of subsidiaries	Petroleum: Book value end of year	All industries: Book value beginning of year	All industries: Net capital outflows	All industries: Undistributed earnings of subsidiaries	All industries: Book value end of year
Developed countries[1]	18,334	1,183	841	20,336	83,025	2,883	5,149	91,139
Canada	5,731	-54	534	6,209	28,404	482	2,227	31,155
Europe	9,960	1,262	179	11,381	44,782	2,265	2,525	49,621
Japan	1,367	-87	33	1,314	3,319	-40	52	3,328
Australia, New Zealand, South Africa, Republic of	1,275	63	94	1,432	6,520	177	345	7,035
Developing countries[1]	8,257	1,903	1,158	11,147	28,459	3,713	2,928	34,874
Latin America Republics and other Western Hemisphere	3,564	-233	89	3,370	19,491	1,347	1,462	22,223
Other Africa	1,346	-113	139	1,337	2,233	18	181	2,397
Middle East	1,613	2,034	23	3,673	2,215	2,144	149	4,508
Other Asia and Pacific	1,734	215	902	2,766	4,519	204	1,136	5,746
International, unallocated	3,605	-283	3	3,324	7,335	-288	107	7,155
Total[1]	30,195	2,803	2,001	34,806	118,819	6,307	8,184	133,168

[p]Preliminary.
[1]Data may not add to totals shown because of independent rounding.

Source: U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. V. 56, No. 8, August 1976, p. 48, table 13; p. 49, table 14; p. 51, table 16; p. 53, table 18.

Table 46.—Direct private investments of U.S. companies in foreign mining and smelting industries in 1975[p]

(Million dollars; net inflows to the United States designated by -)

Area or country	Book value at yearend	Net capital outflows	Undistributed earnings of subsidiaries	Earnings[1]	Income[2]
Developed countries[3]	4,407	205	197	478	295
Canada	3,058	101	156	243	100
Europe	41	6	-2	-3	([4])
Australia, New Zealand, South Africa, Republic of	1,308	98	43	238	196
Australia	1,063	77	41	230	189
South Africa, Republic of	W	21	2	7	7
Developing countries[3]	2,145	342	41	152	147
Latin American Republics	1,012	250	32	20	([4])
Mexico	80	-13	11	17	6
Panama	-1	([4])	([4])	([4])	([4])
Brazil	131	17	20	W	W
Chile	13	W	W	W	([4])
Peru	700	W	W	-42	-26
Other Western Hemisphere	460	59	([4])	80	86
Other Africa	486	36	10	38	W
Middle East	5	1	2	2	([4])
Other Asia and Pacific	181	-3	-3	12	W
Total[3]	6,551	547	238	630	442

[p]Preliminary. W Withheld to avoid disclosing individual company confidential data.
[1]Sum of the U.S. share in net earnings of subsidiaries and branch profits.
[2]Sum of dividends, interest, and branch profits.
[3]Data may not add to totals shown because of independent rounding.
[4]Less than 1/2 unit.

Source: U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. V. 56, No. 8, August 1976, p. 49, table 14; p. 51, table 16; p. 53, table 18; p. 55, table 20; p. 59, table 24.

Table 47.—Value of foreign direct investments in the United States, at yearend

(Million dollars)

Industry	1971	1972	1973	1974	1975[p]
Total	13,655	14,868	18,284	22,421	26,740
Petroleum	3,113	3,272	4,649	5,979	8,194

[p]Preliminary.

Source: U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. V. 54, No. 8, Part 2, August 1974, p. 7, table 1; v. 56, No. 8, August 1976, p. 34, table 1.

Table 48.—Mineral freight originated on rail and water carriers in the United States, including Puerto Rico and Virgin Islands

(Thousand short tons)

Mineral group	Rail			Water		
	1974	1975	Percent change from 1974	1974	1975	Percent change from 1974
Metals and minerals, except fuels:						
Bauxite	6,733	5,176	-23	583	447	-23
Copper ores	10,812	6,568	-39	--	19	--
Iron ores and concentrates	103,132	89,642	-13	79,893	69,325	-13
Lead and zinc ores	2,077	1,698	-18	NA	NA	NA
Manganese ores	1,071	848	-21	1,186	1,117	-6
Other ores	2,690	2,513	-7	631	672	+6
Steel works and rolling mill products	56,001	41,017	-27	11,264	8,707	-23
Iron and steel castings	2,959	2,227	-25	--	--	--
Nonferrous metals, primary smelting products	7,389	5,075	-31	680	548	-19
Other primary metal products	3,970	3,060	-23	--	--	--
Iron and steel scrap	38,872	28,946	-26	2,311	1,554	-33
Nonferrous metal scrap	449	2,088	+365	87	36	-59
Abrasives, asbestos, etc	32,276	27,480	-15	--	--	--
Cement	17,681	15,405	-13	9,873	8,299	-16
Clay	3,311	2,641	-20	1,694	1,480	-13
Fertilizer	19,633	18,481	-6	6,128	6,001	-2
Gypsum	2,035	1,455	-28	709	620	-13
Limestone, agricultural and lime	8,791	7,378	-16	675	481	-29
Limestone, flux	11,693	9,081	-22	36,316	29,134	-20
Phosphate rock	41,909	42,238	+1	8,535	9,412	+10
Sand and gravel	48,349	39,772	-18	76,444	67,906	-11
Stone, crushed	45,679	38,814	-15	--	--	--
Sulfur	5,102	4,818	-6	8,842	8,057	-9
Other nonmetallic minerals	11,031	10,180	-8	7,052	6,627	-6
Total minerals, excluding fuels	483,645	406,601	-16	252,903	220,442	-13
Fuels and related products:						
Asphalt, tar and pitches	2,988	2,556	-14	8,950	8,075	-10
Coal	390,871	407,566	+4	144,779	152,814	+6
Coke	23,546	19,720	-16	2,412	2,394	-1
Crude petroleum and natural gas	2,746	2,900	+6	83,580	77,887	-7
Distillate fuel oil	1,101	784	-29	83,573	86,994	+4
Gasoline, jet fuel, kerosine	1,349	1,229	-9	105,457	106,530	+1
Liquefied petroleum gas, coal gas	6,979	6,445	-8	1,135	1,378	+21
Residual fuel oil	7,097	6,626	-7	111,468	111,504	--
Other petroleum and coal products	9,963	8,404	-16	13,285	11,596	-13
Total fuel and related products	446,640	456,230	+2	554,639	559,172	+1
Total minerals	930,285	862,831	-7	807,542	779,614	-3
All products carried	1,530,686	1,395,055	-9	982,700	946,327	-4
Mineral products, percent of grand total:						
Metals and minerals, except fuels	32	29	--	26	23	--
Fuels and related products	29	33	--	56	59	--
Total minerals	61	62	--	82	82	--

NA Not available.

Source: Interstate Commerce Commission, Bureau of Accounts, Freight Commodity Statistics, Class I Railroads in the United States, 1974 and 1975. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Part 5. National Summaries, table 2, 1974 and 1975.

Table 49.—Percentage distribution of mine shipments of bituminous coal and lignite by method of shipment and mine use

Year	Shipped by rail and trucked to rail	Shipped by water and trucked to water	Trucked to final destination	Used at mines[1]	Total production
1972	66.2	11.7	11.0	11.1	100.0
1973	67.1	11.5	9.8	11.6	100.0
1974	[2]77.1	([2])	11.0	11.9	100.0
1975	64.5	10.7	12.2	12.6	100.0
1976	63.0	11.0	13.0	13.0	100.0

[1]Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.

[2]Bituminous coal and lignite shipped by water included with that shipped by rail.

Table 50.—Miles of utility gas main, by type of main [1]

(Thousands)

Type of main	1971	1972[r]	1973[r]	1974[r]	1975	1976[p]
Field and gathering	[r]66.2	66.9	65.9	66.4	68.5	70.3
Transmission	254.8	258.1	263.1	262.2	262.6	258.2
Distribution	[r]610.4	623.1	633.8	645.6	648.9	659.1
Total[2]	[r]931.4	948.1	962.9	974.1	980.0	987.7

[p]Preliminary. [r]Revised.
[1]Excludes service pipe. Data not adjusted to common diameter equivalent. Mileage shown as of end of each year.
[2]Data may not add to totals shown because of independent rounding.

Source: American Gas Association. Gas Facts, a Statistical Record of the Gas Utility Industry in 1975, p. 49, table 42, 1976 data obtained directly from the American Gas Association.

Table 51.—Petroleum pipelines, selected years

(Miles)

Year	Trunklines		Gathering lines	Total
	Crude	Products		
1962	70,355	53,200	76,988	200,543
1965	72,383	61,443	77,041	210,867
1968	70,825	64,529	74,124	209,478
1971	75,143	72,396	71,132	218,671
1974	76,250	76,839	69,266	222,355

Table 52.—Funds expended in research and development activity

(Million dollars)

Industry	Total[1]			Company			Federal Government		
	1973	1974	1975	1973	1974	1975	1973	1974	1975
Petroleum refining and extraction	504	598	700	490	578	669	14	20	31
Percent of all industries	2.4	2.7	3.0	3.9	4.1	4.5	0.2	0.2	0.4
Chemicals and allied products	2,081	2,364	2,650	1,875	2,148	2,411	206	216	240
Percent of all industries	9.9	10.6	11.3	14.8	15.3	16.3	2.5	2.6	2.7
All industries	20,921	22,348	23,535	12,699	14,018	14,775	8,222	8,329	8,761

[1]Data may not add to totals shown because of independent rounding.

Source: National Science Foundation. Science Resources Studies Highlights. NSF 76-324, Oct. 27, 1976, p. 2.

Table 53.—Federal obligated funds for metallurgy and materials research

(Thousand dollars)

Federal agency	Fiscal year 1976[e]			Fiscal year 1977[e]		
	Basic research	Applied research	Total research	Basic research	Applied research	Total research
Department of Defense	29,737	80,308	110,045	35,330	85,432	120,762
Energy Research and Development Administration	40,212	13,226	53,438	42,796	22,104	64,900
National Aeronautics and Space Administration	7,259	34,712	41,971	7,867	36,065	43,932
Bureau of Mines	135	43,420	43,555	100	38,470	38,570
National Science Foundation	16,671	2,135	18,806	18,981	2,367	21,348
Department of Commerce	999	1,156	2,155	1,030	1,192	2,222
Other	5	564	569	10	763	773
Total	95,018	175,521	270,539	106,114	186,393	292,507

[e]Estimate.

Source: National Science Foundation. Federal Funds for Research, Development and Other Scientific Activities, Fiscal Years 1975, 1976, and 1977, v. XXV, Detailed Statistical Tables, Appendices C and D. NSF 76-315, July 1976, tables C-24, C-25, C-43, C-44, C-62, C-63.

Table 54.—Bureau of Mines obligations for mining and mineral research and development

(Thousand dollars)

Fiscal year	Applied research	Basic re-search	Devel-op-ment	Total
1973	34,591	6,863	36,053	77,507
1974	24,880	5,637	35,590	66,107
1975	50,977	1,935	48,717	101,629
1976	72,500	800	58,000	131,300
T.Q.[1]	24,300	200	20,300	44,800
1977[e]	78,900	800	65,378	53,706

[e]Estimate.
[1]Transition quarter, July 1-Sept. 30, 1976.

Table 55.—Bureau of Mines obligations for total research, by field of science

(Thousand dollars)

Field	Fiscal Year			
	1975	1976	T.Q.[1]	1977[e]
Engineering sciences	47,712	67,520	23,030	73,820
Physical sciences	1,885	1,780	470	1,880
Mathematical sciences	1,285	1,600	400	1,600
Environmental sciences	2,030	2,400	600	2,400
Total	52,912	73,300	24,500	79,700

[e]Estimate.
[1]Transition quarter, July 1-Sept. 30, 1976.

Table 56.—Summary of Government inventories of strategic and critical materials December 31, 1976

	Acquisition cost	Market value[1]
Total inventories in storage:		
National stockpile	$2,479,153,000	$6,013,865,200
Supplemental stockpile	1,076,059,600	1,899,874,700
Defense Production Act	297,095,800	246,683,900
Total	3,852,308,400	8,160,423,800
Total inventories reserved for goals and uncommitted excess inventories	NA	6,410,079,700

NA Not available
[1]Market values are computed from prices at which similar materials are being traded; or in the absence of current trading, at an estimate of the price that would prevail in commercial markets. Prices used are unadjusted for normal premiums and discounts relating to contained qualities, or for inherent materials-handling allowances. Market values do not necessarily reflect the amount that would be realized at time of sale. The uncommitted excess excludes the unshipped sales; the inventories in storage include quantities that have been sold but not shipped.

Source: General Services Administration, Office of Preparedness. Stockpile Report to the Congress: Preliminary Data for the Statistical Supplement, October-March fiscal year 1977.

Table 57.—U.S. Government stockpile disposal of mineral commodities, 1976

Commodity	Sales commitments	
	Quantity	Sales value
NATIONAL AND SUPPLEMENTAL STOCKPILE INVENTORIES		
Aluminum short tons	9,765	$7,950,713
Aluminum oxide, fused, crude do	16,973	3,063,796
Asbestos, amosite do	192	66,112
Asbestos, crocidolite do	4	[1]2,904
Cadmium pounds	125,000	241,999
Cobalt do	5,148,660	20,799,141
Columbium ores and concentrates do	24,819	78,682
Copper, oxygen free, high conductivity short tons	500	700,000
Copper, other do	[1]--	[1]-1,044,443
Diamonds, industrial, bort carats	2,542,923	5,540,158
Diamonds, industrial, stone do	[1]-576	6,108,154
Lead short tons	459	167,076
Magnesium do	500	835,000
Manganese, battery grade, natural ore short dry tons	123	6,150
Manganese, battery grade, synthetic dioxide do	545	231,127
Manganese, chemical grade, type A do	1,000	65,250
Manganese, chemical grade, type B do	6,000	420,360
Mica, muscovite film pounds	18,823	73,416
Mica, muscovite splittings do	1,186,078	1,188,006
Mica, phlogopite block do	19,112	13,001
Mica, phlogopite splittings do	357,975	203,943
Molybdenum disulfide do	130,151	[1]912,297
Molybdenum, ferro do	--	[1]35,086
Molybdenum oxide do	--	[1]5,600
Quartz crystals do	234,392	1,479,533
Rare earths short dry tons	55	26,125
Selenium pounds	2,500	42,529
Talc short tons	30	9,200
Thorium nitrate pounds	17,800	40,056
Tin long tons	3,586	26,282,833
Tungsten ores and concentrates pounds	2,281,130	14,530,844
Total	--	90,074,648
DEFENSE PRODUCTION ACT (DPA) INVENTORY		
Cobalt pounds	24,199	122,399
Columbium ores and concentrate do	44,089	142,801
Manganese, metallurgical grade short dry tons	42,660	912,855
Mica, muscovite film pounds	991	4,645
Tungsten ores and concentrate do	1,427,277	9,399,150
Total	--	10,581,850
OTHER		
Lithium pounds	1,983,869	1,521,290
Mercury flask	1,020	113,690
Total	--	1,634,980
Grand total	--	102,291,478

[1]Represents adjustments to prior year contracts.

Source: General Services Administration, Federal Preparedness Agency. Stockpile Report to the Congress, January-June 1976; July-September, 1976; Preliminary data for the Statistical Supplement, October-March fiscal year 1977.

Table 58.—United Nations indexes of world[1] mineral industry production

(1970=100)

Industry sector and geographical area	1974	1975	1976	1976 by quarter 1st	2d	3d	4th
EXTRACTIVE INDUSTRIES							
Metals:							
Market economy countries	104	98	101	98	101	102	104
Developed[2]	100	94	96	92	98	98	98
United States and Canada	104	95	101	94	104	103	102
Europe	106	100	98	101	102	90	98
European Economic Community[3]	88	83	77	81	80	71	75
European Free Trade Association[4]	119	108	110	118	119	96	113
Australia and New Zealand	102	104	101	90	97	113	103
Developing[5]	111	103	109	109	106	109	113
Latin America[6]	118	108	116	118	109	113	122
Asia[7]	95	96	99	97	99	98	102
Centrally planned economy countries (Europe)[8]	119	122	123	122	125	123	121
World	108	103	106	104	107	107	108
Coal:							
Market economy countries	85	88	88	91	88	81	92
Developed[2]	83	85	85	88	86	78	89
United States and Canada	102	112	114	114	118	106	119
Europe	76	77	76	80	75	68	80
European Economic Community[3]	74	74	72	77	72	64	76
European Free Trade Association[4]	97	90	91	96	88	89	92
Australia and New Zealand	132	131	145	134	150	145	151
Developing[5]	113	122	124	134	121	117	124
Latin America[6]	118	117	114	NA	NA	NA	NA
Asia[7]	112	125	131	146	126	124	128
Centrally planned economy countries (Europe)[8]	110	114	116	115	117	116	117
World	96	99	100	102	101	96	103
Crude petroleum and natural gas:							
Market economy countries	122	116	125	122	120	125	132
Developed[2]	112	114	114	117	111	110	121
United States and Canada	103	106	104	104	102	103	107
Europe	158	159	178	204	157	138	213
European Economic Community[3]	164	166	187	216	164	142	227
European Free Trade Association[4]	NA	NA	NA	NA	NA	NA	NA
Australia and New Zealand	NA	NA	NA	NA	NA	NA	NA
Developing[5]	129	117	132	126	126	135	140
Latin America[6]	100	94	94	99	93	97	89
Asia[7]	100	94	94	99	93	97	89
Centrally planned economy countries (Europe)[8]	130	140	148	141	140	142	136
World	124	121	130	128	126	130	135
Total extractive industry:							
Market economy countries	112	107	114	111	111	113	119
Developed[2]	104	102	104	104	103	102	109
United States and Canada	104	105	106	105	105	103	106
Europe	99	95	98	103	96	90	104
European Economic Community[3]	97	93	96	102	93	86	102
European Free Trade Association[4]	111	104	106	109	110	96	107
Australia and New Zealand	144	142	144	134	143	150	148
Developing[5]	125	114	127	122	122	129	134
Latin America[6]	108	102	104	107	101	104	102
Asia[7]	148	134	152	145	144	155	166
Centrally planned economy countries (Europe)[8]	124	132	138	136	139	139	136
World	116	115	121	118	119	121	124
PROCESSING INDUSTRIES							
Base metals:							
Market economy countries	120	102	111	107	116	110	112
Developed[2]	118	99	107	104	112	105	107
United States and Canada	115	92	101	99	109	100	94
Europe	117	99	107	106	111	101	111
European Economic Community[3]	112	93	101	101	104	96	104
European Free Trade Association[4]	116	101	104	101	107	95	112
Australia and New Zealand	111	109	109	109	114	111	102
Developing[5]	136	142	159	141	161	167	167
Latin America[6]	145	148	161	139	164	171	169
Asia[7]	121	135	164	150	161	172	174
Centrally planned economy countries (Europe)[8]	126	135	146	149	148	145	143
World	121	112	121	119	125	120	121

See footnotes at end of table.

Table 58.—United Nations indexes of world[1] mineral industry production —Continued

(1970=100)

Industry sector and geographical area	1974	1975	1976	1976 by quarter 1st	2d	3d	4th
PROCESSING INDUSTRIES —Continued							
Nonmetallic mineral products:							
Market economy countries	121	114	124	113	127	126	128
Developed[2]	118	109	118	108	122	120	123
United States and Canada	120	110	124	112	126	129	127
Europe	118	109	116	106	122	114	120
European Economic Community[3]	116	106	113	104	119	110	118
European Free Trade Association[4]	119	101	102	93	107	98	110
Australia and New Zealand	114	116	126	110	128	132	134
Developing[5]	139	146	158	147	161	168	158
Latin America[6]	143	151	165	155	166	178	162
Asia[7]	135	141	152	138	157	156	156
Centrally planned economy countries (Europe)[8]	135	144	152	150	156	153	150
World	126	126	135	128	138	137	137
Chemicals, petroleum, and coal products:							
Market economy countries	130	123	138	134	138	137	143
Developed[2]	129	121	137	133	138	135	141
United States and Canada	128	125	143	138	154	144	147
Europe	131	117	132	131	134	126	136
European Economic Community[3]	128	113	128	128	131	123	131
European Free Trade Association[4]	128	116	127	124	131	117	135
Australia and New Zealand	124	116	127	117	128	131	132
Developing[5]	137	136	146	139	144	150	152
Latin America[6]	144	143	154	NA	NA	NA	NA
Asia[7]	125	122	130	126	125	133	138
Centrally planned economy countries (Europe)[8]	146	161	175	173	178	176	172
World	134	132	146	143	147	146	150
OVERALL INDUSTRIAL PRODUCTION							
Market economy countries	121	115	125	122	126	123	130
Developed[2]	119	112	122	119	122	119	126
United States and Canada	119	112	124	120	125	124	125
Europe	118	111	119	118	120	110	127
European Economic Community[3]	115	108	116	116	117	107	124
European Free Trade Association[4]	119	112	113	112	116	102	123
Australia and New Zealand	116	117	122	114	122	126	124
Developing[5]	135	136	148	139	146	151	155
Latin America[6]	141	144	154	NA	NA	NA	NA
Asia[7]	139	140	157	149	152	158	168
Centrally planned economy countries (Europe)[8]	140	152	164	161	165	164	164
World	126	125	136	132	137	134	140

NA Not available.

[1]Excludes Albania, the People's Republic of China, Mongolia, North Korea, and Vietnam.

[2]Canada, the United States, all countries of Europe (except those listed in footnotes 1 and 8), the Republic of South Africa, Israel, Japan, Australia, and New Zealand.

[3]Belgium, Denmark, France, West Germany, Ireland, Italy, Luxembourg, the Netherlands, and the United Kingdom.

[4]Austria, Norway, Portugal, Sweden, and Switzerland.

[5]Countries not indicated in the footnotes 1, 2, and 8.

[6]Corresponds to the United Nations classifications "Carribean, Central and South America."

[7]Corresponds to the United Nations classifications "Asia, excluding Israel and Japan."

[8]Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, and the U.S.S.R.

Source: United Nations Monthly Bulletin of Statistics. August 1977, pp. xiv-xxvii.

Table 59.—Comparisons of world production and U.S. production and imports of principal minerals and mineral fuels in 1976

(Thousand short tons, unless otherwise specified)

Commodity and unit	World production[p]	Percent of world production			
		U.S. production	U.S. imports	Total U.S. production and imports	
				1975	1976
METALLIC ORES AND CONCENTRATES					
Bauxite thousand long tons	76,337	2.6	[1]16.5	18.1	19.1
Chromite	9,492	--	13.4	13.8	13.4
Copper (content of ore and concentrate)	8,213	19.6	6.5	22.6	26.1
Iron ore thousand long tons	881,028	9.1	5.0	13.9	14.1
Lead (content of ore and concentrate)	3,701	16.5	2.4	17.8	18.9
Mercury thousand 76-pound flasks	244	9.4	18.0	20.3	27.4
Molybdenum (content of ore and concentrate)[2] thousand pounds	191,287	59.2	1.0	61.6	60.2
Nickel (content of ore and concentrate)	886	1.8	21.2	20.5	23.0
Platinum-group (Pt, Pd, etc.) thousand troy ounces	5,992	.1	44.5	32.2	44.6
Silver do	304,899	11.3	29.0	42.1	40.3
Titanium concentrates:					
Ilmenite (excluding slag)	3,512	18.6	4.8	26.1	23.4
Rutile[3]	471	W	59.9	NA	NA
Tungsten (content of ore and concentrate) thousand pounds	91,845	6.3	5.8	14.4	12.1
Zinc (content of ore and concentrate)	6,462	7.5	2.4	14.0	9.9
METALS, SMELTER BASIS					
Aluminum	13,774	30.9	5.4	33.2	36.3
Copper	8,164	17.9	5.7	20.5	22.6
Iron, pig	549,298	15.8	.1	15.2	15.9
Lead	3,788	15.0	3.7	17.2	18.7
Magnesium	148	W	10.1	NA	NA
Steel, raw	748,492	17.1	1.7	18.1	18.8
Tin thousand metric tons	229	2.5	19.7	22.0	22.3
Uranium oxide[4] short tons	30,100	42.2	18.4	48.1	60.6
Zinc	5,978	6.4	11.6	12.2	18.0
NONMETALS					
Asbestos	5,566	2.1	11.8	14.0	13.9
Cement	811,502	9.0	.4	9.3	9.4
Diamond thousand carats	39,726	--	56.9	45.9	56.9
Feldspar, crude	2,850	26.0	([6])	23.2	26.0
Fluorspar, marketable	4,889	3.8	18.3	23.7	22.1
Gypsum	66,231	18.1	9.4	24.2	27.5
Mica (including scrap) thousand pounds	471,082	53.5	1.1	52.7	54.6
Nitrogen, agricultural[5]	48,366	28.7	2.9	31.9	31.6
Phosphate rock	117,898	41.5	([6])	41.5	41.5
Potash (K_2O equivalent)	26,876	8.9	17.1	23.0	26.0
Salt[7]	183,252	24.0	2.2	25.3	26.2
Sulfur thousand long tons	50,070	21.4	3.4	26.2	24.8
MINERAL ENERGY RESOURCES					
Crude petroleum thousand barrels	21,187,147	14.0	12.6	27.0	26.6
Natural gas, marketed million cubic feet	49,352,023	40.4	2.0	44.4	42.4
Bituminous coal and lignite	3,515,048	19.3	([6])	19.0	19.3
Anthracite	196,769	3.2	--	3.2	3.2

[p]Preliminary. NA Not available. W Withheld to avoid disclosing individual company confidential data.
[1]Includes imports into U.S. Virgin Islands.
[2]World total exclusive of Bulgaria and China.
[3]World total exclusive of the United States.
[4]World total exclusive of Brazil, Czechoslovakia, Finland, East Germany, West Germany, Hungary, India, Israel, Japan, the People's Republic of China, and the U.S.S.R.
[5]For year ending June 30 of year stated.
[6]Less than 1/2 unit.
[7]Includes Puerto Rico.

Table 60.—Value of world export trade in major mineral commodity groups[1]

(Million U.S. dollars)

Commodity group	1971[r]	1972[r]	1973[r]	1974[r]	1975
Metals:					
All ores, concentrates, scrap	7,231	7,762	11,017	15,683	14,685
Iron and steel	17,705	20,102	28,455	46,435	45,831
Nonferrous metals	10,489	11,862	17,284	25,221	18,243
Subtotal	35,425	39,726	56,756	87,339	78,759
Nonmetals (crude only)	2,743	3,197	3,840	5,856	6,257
Mineral fuels	36,153	42,104	63,565	168,104	168,560
Total	74,321	85,027	124,161	261,299	253,576
All commodities	346,271	413,837	574,093	833,290	872,528

[r]Revised.

[1]Data presented are for selected major commodity groups of the Standard International Trade Classification—Revised (SITC-R), and as such exclude some mineral commodities classified in that data array together with other (nonmetal) commodities. SITC-R categories, included are as follows: Ores, concentrates, and scrap—SITC Division 28; iron and steel—SITC Division 67; nonferrous metals—SITC Division 68; nonmetals (crude only)—SITC Division 27; mineral fuels—SITC Division 3. Major items not included are the metals, metalloids, and metal oxides of SITC Division 52; mineral tar and crude chemicals from coal, petroleum and natural gas of SITC Division 52; manufactured fertilizers of SITC Division 56; and nonmetallic mineral manufactures of SITC Divisions 661,662, 663, and 667. Data includes special category exports, ship's stores and bunkers and other exports of minor importance, and excludes the inter-trade of the centrally planned economies of Asia and trade between West Germany and East Germany.

Source: United Nations Monthly Bulletin of Statistics. V. 31, No. 5, May 1977, pp. xxviii-lii.

Table 61.—Mineral commodity export price indexes

(1970=100)

Year and quarter	Metal ores	Fuels	All crude minerals
1974	175	577	473
1975	[r]206	588	494
1976:			
First quarter	199	628	517
Second quarter	218	610	506
Third quarter	213	610	508
Fourth quarter	NA	NA	511
Annual average	NA	NA	510

[r]Revised. NA Not available.

Sources: United Nations Monthly Bulletin of Statistics, New York, December 1976 and October 1977.

Table 62.—Analysis of export price indexes

(1970=100)

Year and quarter	Developed areas		Developing areas	
	Total minerals	Nonferrous base metals	Total minerals	Nonferrous base metals
1974	274	149	555	160
1975	301	125	571	109
1976:				
First quarter	299	126	605	108
Second quarter	299	138	590	127
Third quarter	301	145	591	134
Fourth quarter	NA	NA	NA	NA
Annual average	NA	NA	NA	NA

NA Not available.

Source: United Nations Monthly Bulletin of Statistics, New York, December 1976, pp. xxv-xxvi.

Mining and Quarrying Trends in the Metal and Nonmetal Industries

By T. A. Johnson[1]

Recovering from low demand in 1975, raw mineral production in the United States maintained a steady climb in value and quantity throughout 1976, keeping pace with the gross national product (GNP), which increased 11.5% compared with that of 1975. The minerals industry, in the past, has met ever-increasing demand while keeping production costs to a minimum. To maintain this capability, technological research and development of more efficient processing methods must continue.

The role of Government and its increasing involvement in minerals industry actions received unfavorable comment from various segments of the industry in 1976. Government pricing controls were of concern to most industrial firms marketing like products. Public land withdrawals in large blocks were of concern to the mineral industry.

The large amounts of capital and the length of time required to bring a new facility into production were also of concern. For the latter, estimates from conception to realization were as much as 15 years. Capital outlay for the mineral industry in the past few years has increased from $25-$30 to $75-$90 per ton of output.

In underground mining, raise- and shaft-boring methods have been perfected and 1,000-foot borings are common. Because Federal regulations require better air quality, mine operators throughout the United States are engaged in improving mine ventilation systems. The safer and more rapid completion of 7-foot-diameter shafts at lower costs, compared with the more conventional shaft-sinking methods, have contributed toward the use of raise-boring for constructing mine ventilation shafts. Longer cutter life has also advanced this method; often 3,000 to 5,000 feet of boring can be completed before cutters must be replaced. The trend in boring is toward larger diameters, with 15-foot diameter shafts being the next size in certain rock formations. The largest and longest raise bored, to date, is the 2,300-foot-long, 12-foot-diameter shaft at the Cargill salt mine in New York State.

Roof control in underground mining remains a problem, owing to the increased depth of mines. The Bureau of Mines, in cooperation with the mining industry, has researched methods to monitor and predict roof falls. Utilizing a computer, the Bureau constructed and installed an instrumentation system whereby up to 400 underground locations were monitored simultaneously. The computer automatically plotted load, deformation, stresses, and closures as desired. Additional support was installed in suspected unsafe locations.

Research and development of more efficient underground drilling equipment continued. Interest in the all-hydraulic drill, which has only one moving part and provides the capability for drilling larger diameter holes, has increased. The percussive drills presently used are limited to 2 to 2 1/2-inch-diameter holes, because larger holes would require much bulkier machines, commensurately larger rods, and greater compressor capacity. In addition, research was being directed toward radical-

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ly different drilling techniques, such as laser-assisted drilling and high-pressure, jet-assisted mechanical drilling. In the former, the laser beam performs the "kerfing" at the same time as the conventional drill bit cuts the hole gauge. In the latter, the high-pressure water jet is placed slightly ahead of the rotary bit to increase the penetration rate.

Advances in blasting technology were oriented toward pattern selection rather than explosive development. The trend at present is also toward higher benches, larger diameter holes, and delay blasting. Metallized slurries, however, will increasingly be used in underground blasting in the future because of higher blasting efficiency.

The mining industry has continued to adopt new methods for underground loading and haulage, as evidenced by the increasing use of trackless haulage and the development of conveyor technology. It is estimated that 5,000 to 6,000 diesel load-haul-dump (LHD) units are presently in use in the hard-rock sector. These units are characterized by their high productivity, flexibility, and low initial cost. The design trends for the LHD's are toward lower profiles, power-shift transmissions, articulated steering, and fast-reversing units. Environmental constraints have led to the development of more effective exhaust systems and electrically powered units.

Environmental constraints have influenced the search for future uses of mined out areas. One such area has been converted into an industrial park with warehouses, factories, and offices. In the past, mined out areas have been used for oil and water storage and as nurseries for seedling pine trees. Often, possible future uses for the mined space are taken into consideration in the planning stages of mine design. Storage and waste disposal areas are of primary interest.

Companies engaged in surface mining and processing are experimenting with new methods for increased and more efficient production. Computer systems for the evaluation of deposits and the design of open pits are being used by an increasing number of companies. Equipment changes in open pit mining have not been drastic, although most taconite companies have changed from jet-piercers to large rotary drills for blastholes. For haulage, the average operation utilizes 50- to 170-ton trucks. In the smaller open pit operations, the trend is toward the use of front-end-loaders rather than power shovels. Where shovels are used, the shift is to hydraulic machines. The main advantages of the hydraulic shovels are lower overall weight and the fact that the bucket may be loaded by rotation rather than by being drawn through the bank. The bucket-wheel excavator, in conjunction with a conveyor system is finding favor where material to be stripped is relatively soft and needs to be transported long distances. Use of bucket-wheel excavators for reclaiming stockpiled material such as iron ore is also increasing. However, where flexibility is needed, truck transport is still the preferred method.

In the processing sector, computer control is becoming more common. Advantages cited include better recoveries, increased throughput, and improved grade. Use of autogenous grinding and high-intensity magnetic separation is increasing. Plant design trends for processing equipment are toward larger machines owing to reduced total capital outlays for equipment, foundations, buildings, piping, and instrumentation.

The Bureau of Mines continued its pilot plant research of Western Mesabi Range nonmagnetic taconites, using processes such as reduction roasting, high-intensity magnetic separation, selective flocculation, desliming, and cationic flotation. From a 34% iron feed, a concentrate containing 63% iron, and less than 5.5% silica was produced with an iron recovery of about 75%. The results obtained indicate that these taconites may be a future source of iron ore on the Mesabi Range. Investigations by the Bureau of Mines were also continuing on the use of various coals as substitutes for gas or oil for pellet induration.

Mineral processing will be faced with greater restraints on water pollution and noise pollution in the future. Many plants are installing water treatment facilities. To comply with the maximum daily noise emission levels as recommended by the U.S. Mining Enforcement and Safety Administration, rubber liners in grinding mills and rubber screen cloths on screens will be used. In addition dumps and mined out areas will be reclaimed for industrial or residential development.

Magnitude of the Mining Industry.—The number of metal and nonmetal mines increased from 15,014 in 1975 to 15,279 in 1976; of the 265 additional mines, 15, were metal and 250 were nonmetal.

In 1976, the number of mines that produced more than 10 million tons of crude ore totaled 25, the same as in 1975. The increase of one mine in the metal mines category was offset by the decrease by one in the number of nonmetal mines. The principal commodities produced in these mines were copper (10 mines), and gold (5), phosphate rock (5), and sand and gravel (2).

Crude ore output in 1976 totaled 2.7 billion tons, an increase of 5% compared with that of 1975. Total material handled was 4.4 billion tons, an increase of 5% compared with that of 1975.

Output of crude ore from the 25 leading metal mines totaled 437 million short tons, an increase of 8.4% compared with that of 1975. Output of crude ore from the 25 leading nonmetal mines totaled 200 million short tons, a decrease of 5.7% compared with that of 1975.

The Minntac iron ore mine of the United States Steel Corp., the Erie Commercial iron ore mine of Pickands Mather & Co., and the Sierrita copper mine of Duval Sierrita Corp. headed the list of metal mines in output of crude ore. Three phosphate mines—Swift Creek mine of the Occidental Chemical Corp. and the Kingsford and Noralyn mines of the International Minerals & Chemical Corp.—were the leading producers of crude nonmetal ore.

The Utah Copper mine of Kennecott Copper Corp. regained its position as the leading metal mine in total material handled, followed by the Tyrone mine of Phelps Dodge Corp. The Kingsford and Noralyn phosphate mines, both owned by International Minerals & Chemical Corp., were the leading nonmetal mines in total material handled.

The 25 leading metal mines handled a total of 1,263 million short tons of material in 1976, an increase of 3.5% over that of 1975. The 25 leading nonmetal mines handled a total of 432 million short tons of material in 1976, an increase of 6.3% over that of 1975.

In metal mining, copper mines (14) and iron ore mines (9) made up the majority of the 25 leading producers of crude ore, while phosphate rock (14) and stone (9) operations comprised the majority of the 25 largest nonmetal crude ore producers. Copper mines (14), iron ore mines (5), and uranium mines (4), comprised the majority of the 25 leading metal mines in terms of material handled. Phosphate (18) and stone (4) made up the majority of the 25 leading nonmetal mines in total material handled.

Crude ore production of 21 States came entirely from surface mines.

Materials Handled.—The U.S. mineral-producing industry, excluding fuels, handled 4.4 billion tons of crude ore and waste in 1976, an increase of 5% compared with that of 1975. Of the total material handled, crude ore comprised 62%. In 1976, materials handled increased 120 million tons for metal and 100 million tons for nonmetal mines, compared with those of 1975. The largest increase in metals occurred in uranium mining; in nonmetal mining, the largest increase was in sand and gravel.

The amount of waste handled in 1976 totaled 1,660 million tons, a 6% increase compared with that of 1975. This compares with 1,011 million tons of waste handled in 1966 and 1,410 million tons handled in 1970.

Crude ore output at metal mines increased 6% in 1976 over that of 1975; in nonmetal mines crude ore output increased 5%.

Copper, iron ore, uranium, and titanium mines accounted for 89% of the crude ore produced and 93% of the total material handled in metal mining. Phosphate rock, sand and gravel, and crushed stone operations accounted for 94% of the crude ore produced and 92% of the total materials handled in the nonmetals sector.

In 1976, more than 10 million tons of material was handled in each of 10 States, compared with 11 States in 1975. Arizona was the leading State followed by Florida and Minnesota. These three States handled 31% of the U.S. total, and were also the leaders in total crude ore produced.

Value of Principal Mineral Products.—The values shown in table 4 represent crude ore treated or, in the case of some nonmetals, crude ore shipped.

The average value for all commodities increased 8% compared with that of 1975. Of the metal commodities, approximately 55% showed an increase in value and the average value increased 11%. The metal commodities showing the greatest increases were mercury, gold, bauxite, and uranium with silver showing the greatest decrease. For the nonmetal commodities, 78% showed an increase in average value. The overall average value of the nonmetals increased 5% compared with that of 1975. Among the nonmetals, mica, barite, and feldspar showed the largest increases in average value, with diatomite showing the largest decrease.

Byproducts were responsible for increasing the average value of all but three of the metal mine products and all but eight of the nonmetal products, as shown in table 4. The largest additions to average values by byproducts occurred in ores of lead (36%), bauxite (57%), silver (19%), zinc (18%), feldspar (37%), fluorspar (14%), and salt (16%).

In the metal commodities, byproduct values accounted for 17% of the total for underground mines while in the surface mines they accounted for 6% of the average value. In the nonmetal minerals, byproducts from both surface and underground mining contributed about 1% to the average value.

Excluding stone and sand and gravel, average value for nonmetals was 7% higher in 1976 than in 1975, and, for metals and nonmetals combined, the average value was 10% higher.

Ratio of Treated to Marketable Product.—The number of tons of crude ore treated to obtain a unit of marketable product in the metals, varied from a high of 737 for uranium to a low of 0.2 for silver. For most nonmetals, the ratio is generally 1:1. As the higher grade ores approach depletion, the ratio increases. When mining by underground methods, it is essential to keep the ratio as low as possible to maintain minimum costs. In surface mining, the lowest possible ratio is also desirable; however, it is not usually as critical as in underground mining, because labor costs, material-handling costs, and production costs escalate much more rapidly in underground mining than in surface mining.

Comparison of Production From Surface and Underground Mines.—As in previous years, there was little change in the percentages of crude ore mined and total material handled by surface and underground mines. In 1976, surface mines accounted for 94% of the crude ore produced and 96% of the total material handled, the same as in 1975. Crude ore production and total material handled at surface metal mines in 1967 accounted for 83% and 93% of the respective aggregate totals; in 1976, they accounted for 89% of the total crude ore produced and 95% of the total material handled.

Crude iron ore (25%) and copper ore (51%) accounted for more than 75% of the crude ore produced and total material handled by metal mines in 1976.

In the nonmetals sector, surface mines accounted for 96% of the crude ore produced and 96% of the total material handled. Phosphate rock (17%), sand and gravel (36%), and crushed and broken stone (39%), accounted for more than 90% of all crude ore produced and material handled in 1976.

Crude ore production of 10 metals and 22 nonmetals came entirely from surface mines. Underground mines accounted for all production of primary lead, potassium salts, and sodium carbonate.

Exploration and Development.—Development footage increased 14% while exploration footage decreased 41% in 1976, compared with that of 1975. Metal mine exploration work decreased 44% while nonmetal exploration work increased 57%.

Metal mining accounted for 65% of the development footage and 94% of the exploration footage. The major portion of the metals development footage was in uranium, copper, and zinc, accounting for 71% of the total metals development footage. The majority of the nonmetals footage was in phosphate rock and fluorspar ores.

Exploration drilling and trenching for uranium, gold, and copper accounted for 90% of the metals exploration footage. Drilling and trenching for phosphate rock and fluorspar accounted for 72% of the total nonmetals exploration footage.

South Dakota, Wyoming, New Mexico, and Colorado all had over 1 million feet of combined development and exploration activity during 1976. Of the total combined footage of 14.5 million feet, the percentages were: South Dakota, 24%; Wyoming, 20%; New Mexico, 18%; and Colorado 11%. Utah, Missouri, and Montana also had considerable exploration and development footage.

Of the 2.58 million short tons of development material produced, 95% came from stripping. Of this total, Wyoming (40%), New Mexico (22%), and Texas (18%) accounted for most of the material handled. Stripping to uncover uranium, copper, and iron ore produced most of the metals development material; while phosphate rock and gypsum accounted for most of the nonmetallic minerals tonnage. Wyoming had the most footage for drifting, crosscutting, and tunneling development, and Utah had the most raising, and shaft- and winze-sinking development footage.

Explosives.—Continuing the trend of recent years, the apparent U.S. consumption of industrial explosives in 1976 increased 7% compared with that of 1975 to a total of 3,329 million pounds. Coal mining consumed 54% of the total industrial explosives and blasting agents; metal mining and quarrying each consumed 15%. The remaining 16% was consumed in construction and exploration.

Coal mining continued to be the leading consumer of permissible explosives (97% of the total), cylindrically packaged blasting agents (80%), and other processed blasting agents and unprocessed ammonium nitrate (72%). As in previous years, the leading consumer of high explosives was quarrying (53%), and the leading consumer of water gels and slurries was metal mining (66%). Of the 2.78 million pounds of explosives consumed by the minerals industry, coal mining consumed 65%; metal and nonmetal mining consumed 17%, and quarrying, 18%. Each type of mining increased its usage of explosives. The leading consumers of explosives in coal mining by State continued to be Kentucky, Pennsylvania, and Alabama, accounting for 57% of the total. Arizona and Minnesota were the leaders in metal mining (53%), and Pennsylvania, Illinois, and Ohio accounted for 22% of the explosives used in quarrying.

More detailed explosives information may be found in the Annual Explosive issue of Mineral Industry Surveys, prepared by the Division of Nonmetallic Minerals, Minerals Supply/Demand Analysis, Bureau of Mines.

Table 1.—Material handled at surface and underground mines in the United States, by type

(Million short tons)

Type and year	Surface			Underground			All mines[1]		
	Crude ore	Waste	Total[1]	Crude ore	Waste	Total[1]	Crude ore	Waste	Total
Metals:									
1960	336	508	844	86	8	94	421	516	938
1961	340	415	755	83	7	91	423	422	846
1962	346	434	780	76	7	83	422	441	863
1963	354	463	817	76	7	83	430	470	900
1964	376	455	830	83	7	90	458	462	920
1965	390	505	895	87	6	94	477	511	989
1966	412	634	1,050	88	7	95	500	641	1,140
1967	353	619	972	74	7	81	427	626	1,050
1968	402	717	1,120	79	13	92	481	730	1,210
1969	455	941	1,400	85	13	98	540	954	1,490
1970	499	968	1,470	87	7	94	586	975	1,560
1971	480	1,020	1,500	80	6	86	560	1,020	1,580
1972	491	1,080	1,570	86	5	91	576	1,080	1,660
1973	574	1,280	1,860	82	9	91	655	1,290	1,950
1974	547	1,210	1,760	80	11	91	627	1,220	1,850
1975	535	1,170	1,700	74	13	87	609	1,180	1,790
1976	573	1,250	1,820	73	15	87	646	1,260	1,910
Nonmetals:									
1960	1,550	236	1,790	57	1	58	1,610	236	1,850
1961	1,590	188	1,780	65	1	66	1,660	190	1,850
1962	1,590	224	1,810	62	1	63	1,650	225	1,880
1963	1,640	261	1,900	67	2	69	1,710	263	1,970
1964	1,740	277	2,010	69	2	71	1,800	279	2,080
1965	1,850	296	2,140	78	3	81	1,930	299	2,220
1966	1,930	368	2,300	77	2	79	2,010	370	2,380
1967	1,910	399	2,310	78	3	81	1,990	402	2,390
1968	1,870	413	2,280	78	3	81	1,950	416	2,360
1969	2,000	375	2,380	80	2	82	2,080	377	2,460
1970	2,010	431	2,440	80	4	84	2,090	435	2,530
1971	1,980	442	2,420	73	5	78	2,050	447	2,500
1972	2,020	415	2,430	77	5	82	2,100	420	2,520
1973	2,240	418	2,650	82	1	83	2,320	419	2,740
1974	2,220	418	2,640	82	5	87	2,300	423	2,720
1975	1,910	372	2,290	79	6	84	1,990	378	2,370
1976	2,000	393	2,390	80	6	86	2,080	399	2,480
Total metals and nonmetals:[1]									
1960	1,890	744	2,630	143	9	152	2,030	753	2,780
1961	1,930	603	2,540	148	9	156	2,080	612	2,690
1962	1,940	658	2,590	138	8	146	2,070	666	2,740
1963	1,990	724	2,720	142	9	152	2,140	734	2,870
1964	2,110	731	2,840	152	9	161	2,260	740	3,000
1965	2,240	801	3,040	165	9	175	2,400	810	3,210
1966	2,340	1,000	3,340	165	9	174	2,510	1,010	3,520
1967	2,260	1,020	3,280	152	10	162	2,410	1,030	3,440
1968	2,270	1,130	3,400	157	16	173	2,430	1,150	3,580
1969	2,460	1,320	3,770	165	15	180	2,620	1,330	3,950
1970	2,510	1,400	3,910	167	11	178	2,680	1,410	4,090
1971	2,460	1,460	3,920	153	11	164	2,610	1,470	4,080
1972	2,500	1,500	4,000	163	10	173	2,670	1,510	4,180
1973	2,810	1,700	4,510	163	11	174	2,970	1,710	4,680
1974	2,760	1,630	4,390	162	16	178	2,930	1,650	4,570
1975	2,450	1,540	3,990	153	18	171	2,600	1,560	4,160
1976	2,570	1,640	4,210	153	21	174	2,720	1,660	4,390

[1]Data may not add to totals shown because of independent rounding.

Table 2.—Material handled at surface and underground mines in 1976, by commodity[1]

(Thousand short tons)

Commodity	Surface			Underground			All mines[2]		
	Crude ore	Waste	Total[3]	Crude ore	Waste	Total[3]	Crude ore	Waste	Total
METALS									
Bauxite	3,480	14,600	18,000	W	--	W	3,480	14,600	18,000
Copper	257,000	686,000	942,000	25,100	1,360	26,400	282,000	687,000	969,000
Gold:									
Lode	1,340	13,300	14,700	1,710	202	1,910	3,050	13,500	16,600
Placer	4,990	491	5,490	1	(6)	1	5,000	492	5,490
Iron ore	240,000	245,000	485,000	9,640	1,720	11,400	250,000	246,000	496,000
Lead	1	10	11	10,100	2,150	12,300	10,100	2,160	12,300
Mercury	83	656	738	W	--	W	83	656	738
Silver	983	354	1,340	774	317	1,090	1,760	671	2,430
Titanium, ilmenite	36,400	8,760	45,200	--	--	--	36,400	8,760	45,200
Tungsten	83	3	86	593	300	893	675	303	978
Uranium	5,070	253,000	258,000	3,850	4,260	8,110	8,910	257,000	266,000
Zinc	60	52	113	8,290	3,680	12,000	8,350	3,730	12,100
Other[4]	23,700	27,800	51,500	12,800	581	13,300	36,500	28,400	64,900
Total metals[3]	573,000	1,250,000	1,820,000	72,800	14,600	87,400	646,000	1,260,000	1,910,000
NONMETALS									
Abrasives[5]	331	376	707	74	--	74	405	376	781
Asbestos	2,040	250	2,290	W	--	W	2,040	250	2,290
Barite	1,120	995	2,110	W	W	W	1,120	995	2,110
Clays	47,500	e41,300	88,800	692	e10	702	48,200	41,300	89,500
Diatomite	852	6,480	7,330	--	--	--	852	6,480	7,330
Feldspar	1,360	144	1,510	W	W	W	1,360	144	1,510
Fluorspar	24	5	29	586	44	631	610	49	660
Gypsum	10,000	8,950	19,000	2,310	6	2,310	12,300	8,960	21,300
Mica (scrap)	591	406	997	--	--	--	591	406	997
Perlite	722	6	728	W	--	W	722	6	728
Phosphate rock	169,000	242,000	411,000	W	W	W	169,000	242,000	411,000
Potassium salts	--	--	--	17,300	357	17,700	17,300	357	17,700
Pumice	4,140	744	4,890	--	--	--	4,140	744	4,890
Salt	431	61	492	15,100	684	15,700	15,500	745	16,200
Sand and gravel	885,000	--	885,000	--	--	--	885,000	--	885,000
Sodium carbonate (natural)	--	--	--	9,600	4,660	14,300	9,600	4,660	14,300
Stone:									
Crushed and broken	864,000	e71,200	935,000	34,300	e250	34,600	898,000	71,500	970,000
Dimension	e3,050	e1,610	4,660	13	--	13	3,060	1,610	4,670

Talc, soapstone, pyrophyllite	894	2,530	3,430	78	2	80	972	2,530	3,510
Other[6]	6,850	15,600	22,500	379	35	415	7,230	15,700	22,900
Total nonmetals[2]	2,000,000	393,000	2,390,000	80,400	6,050	86,400	2,080,000	399,000	2,480,000
Grand total[2]	2,570,000	1,640,000	4,210,000	153,000	20,600	174,000	2,720,000	1,660,000	4,390,000

[e]Estimate. W Withheld to avoid disclosing individual company confidential data.
[1]Excludes material from wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Antimony, beryllium, manganiferous ore, molybdenum, nickel, platinum-group metals, rare-earth metals, tin, vanadium, and quantity of metal items indicated by symbol W.
[5]Abrasive stone, emery, garnet, and tripoli.
[6]Aplite, boron minerals, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, millstones, olivine, tube-mill liners, vermiculite, wollastonite, and quantity of nonmetal items indicated by symbol W.

Table 3.—Material handled at surface and underground mines (including sand and gravel and stone) in 1976, by State[1]

(Thousand short tons)

State	Surface			Underground			All mines[2]		
	Crude ore	Waste	Total[2]	Crude ore	Waste	Total[2]	Crude ore	Waste	Total
Alabama	38,100	101	38,200	W	--	W	38,100	101	38,200
Alaska	83,800	460	84,200	(3)	(3)	1	83,800	460	84,200
Arizona	200,000	373,000	573,000	18,800	1,060	19,900	218,000	374,000	593,000
Arkansas	37,000	17,000	54,000	521	4	526	37,600	17,000	54,500
California	150,000	54,100	204,000	1,000	181	1,180	151,000	54,300	205,000
Colorado	31,500	13,300	44,800	14,400	3,070	17,500	45,900	16,300	62,200
Connecticut	12,700	15	12,800	--	--	--	12,700	15	12,800
Delaware	1,130	--	1,130	--	--	--	1,130	--	1,130
Florida	231,000	170,000	400,000	--	--	--	231,000	170,000	400,000
Georgia	44,100	515	44,600	831	--	831	44,900	515	45,400
Hawaii	6,990	5	6,990	--	--	--	6,990	5	6,990
Idaho	16,600	30,000	46,600	1,790	393	2,180	18,400	30,400	48,800
Illinois	99,300	5	99,300	2,960	44	3,000	102,000	49	102,000
Indiana	54,700	--	54,700	1,410	--	1,410	56,100	--	56,100
Iowa	46,800	2,090	48,900	1,040	--	1,040	47,800	2,090	49,900
Kansas	27,700	--	27,700	2,780	--	2,780	30,500	--	30,500

See footnotes at end of table.

Table 3.—Material handled at surface and underground mines (including sand and gravel and stone) in 1976, by State[1] —Continued

(Thousand short tons)

State	Surface			Underground			All mines[2]		
	Crude ore	Waste	Total[2]	Crude ore	Waste	Total[2]	Crude ore	Waste	Total
Kentucky	35,900	--	35,900	7,370	--	7,370	43,300	--	43,300
Louisiana	32,800	--	32,800	6,580	133	6,710	39,400	133	39,600
Maine	11,900	--	11,900	W	W	W	11,900	--	11,900
Maryland	29,200	--	29,200	W	--	W	29,200	--	29,200
Massachusetts	24,100	--	24,100	--	--	--	24,100	--	24,100
Michigan	139,000	31,900	171,000	7,150	230	7,380	147,000	32,100	179,000
Minnesota	208,000	163,000	372,000	--	--	--	208,000	163,000	372,000
Mississippi	15,500	--	15,500	--	--	--	15,500	--	15,500
Missouri	57,100	662	57,700	21,200	2,910	24,100	78,300	3,570	81,800
Montana	26,800	47,400	74,200	388	52	441	27,100	47,500	74,600
Nebraska	18,400	--	18,400	W	--	W	18,400	--	18,400
Nevada	26,900	37,200	64,100	197	279	476	27,100	37,400	64,600
New Hampshire	6,960	--	6,960	--	--	--	6,960	--	6,960
New Jersey	33,600	7,340	40,900	208	--	208	33,800	7,340	41,200
New Mexico	49,800	193,000	243,000	20,400	1,910	22,300	70,200	195,000	265,000
New York	61,000	3,320	64,300	5,290	117	5,410	66,300	3,430	69,800
North Carolina	49,400	31,700	81,100	--	--	--	49,400	31,700	81,100
North Dakota	5,210	--	5,210	--	--	--	5,210	--	5,210
Ohio	84,800	6	84,800	4,190	436	4,630	89,000	442	89,400
Oklahoma	30,600	156	30,800	906	--	906	31,500	156	31,700
Oregon	42,600	1,920	44,600	(3)	11	11	42,600	1,930	44,600
Pennsylvania	81,500	2	81,500	6,010	602	6,620	87,500	604	88,100
Rhode Island	3,260	--	3,260	--	--	--	3,260	--	3,260
South Carolina	23,600	--	23,600	--	--	--	23,600	--	23,600
South Dakota	9,870	--	9,870	1,650	165	1,820	11,500	165	11,700
Tennessee	52,100	7,320	59,400	6,630	892	7,520	58,700	8,210	66,900
Texas	111,000	75,000	186,000	319	--	319	111,000	75,000	186,000
Utah	48,000	117,000	165,000	1,290	1,900	3,190	49,300	119,000	168,000
Vermont	5,480	200	5,680	W	W	W	5,480	200	5,680
Virginia	46,400	15	46,400	2,610	930	3,540	49,000	945	50,000
Washington	30,400	3,760	34,200	431	34	464	30,900	3,790	34,700
West Virginia	13,000	--	13,000	2,680	--	2,680	15,700	--	15,700
Wisconsin	53,900	7,760	61,700	W	--	W	53,900	7,760	61,700
Wyoming	18,900	138,000	157,000	10,700	4,910	15,600	29,600	143,000	173,000
Undistributed[4]	1,670	114,000	116,000	1,430	350	1,780	3,100	114,000	118,000
Total[2]	2,570,000	1,640,000	4,210,000	153,000	20,600	174,000	2,720,000	1,660,000	4,390,000

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1]Excludes material from wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Includes estimated data in table 2.

Table 4.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States in 1976

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	By product	Total	Principal mineral product	By product	Total	Principal mineral product	By product	Total
METALS									
Bauxite	$7.48	$9.80	$17.28	W	--	W	$7.48	$9.80	$17.28
Copper	7.41	.75	8.16	$10.69	$1.42	$12.11	7.74	.82	8.56
Gold:									
Lode	21.63	.38	22.01	25.64	.53	26.17	23.76	.45	24.21
Placer	.69	--	.69	--	--	--	.69	--	.69
Iron ore	7.33	--	7.33	15.33	.21	15.54	7.65	.01	7.66
Lead	22.75	12.39	35.14	25.39	14.07	39.46	25.39	14.07	39.46
Mercury	15.16	--	15.16	W	--	W	15.16	--	15.16
Silver	1.17	.87	2.04	55.51	11.98	67.49	25.97	5.94	31.91
Titanium, ilmenite	.75	.65	1.40	--	--	--	.75	.65	1.40
Uranium	40.88	--	40.88	47.15	7.51	54.66	43.71	3.39	47.10
Zinc	--	--	--	30.74	6.62	37.36	30.52	6.57	37.09
Average[1]	7.17	.45	7.62	19.07	3.83	22.90	8.61	.86	9.47
NONMETALS									
Asbestos	10.86	.01	10.87	W	--	W	10.86	.01	10.87
Barite	22.44	.03	22.47	W	--	W	22.44	.03	22.47
Clays	10.22	--	10.22	11.77	--	11.77	10.24	--	10.24
Diatomite	64.54	--	64.54	--	--	--	64.54	--	64.54
Feldspar	12.63	7.52	20.15	W	--	W	12.63	7.52	20.15
Fluorspar	48.53	--	48.53	30.03	5.13	35.16	30.87	4.90	35.77
Gypsum	4.57	.11	4.68	5.98	--	5.98	4.83	.09	4.92
Mica (scrap)	8.14	1.35	9.49	--	--	--	8.14	1.35	9.49
Perlite	15.80	--	15.80	W	--	W	15.80	--	15.80
Phosphate rock	5.60	.07	5.67	W	--	W	5.60	.07	5.67
Potassium salts	--	--	--	9.55	.07	9.62	9.55	.07	9.62
Pumice	2.53	--	2.53	--	--	--	2.53	--	2.53
Salt	2.21	1.03	3.24	7.96	1.55	9.51	7.80	1.53	9.33
Sand and gravel	2.00	--	2.00	--	--	--	2.00	--	2.00
Sodium carbonate (natural)	--	--	--	25.09	--	25.09	25.09	--	25.09
Stone:									
Crushed and broken	2.32	.01	2.33	2.85	--	2.85	2.34	.01	2.35
Dimension	74.19	--	74.19	111.50	--	111.50	74.55	--	74.55
Talc, soapstone, pyrophyllite	8.44	--	8.44	15.30	--	15.30	8.92	--	8.92
Average[1]	2.86	.02	2.88	8.40	.35	8.75	3.07	.03	3.10
Average, metals and nonmetals[1]	3.80	.11	3.91	13.60	2.05	15.65	4.37	.22	4.59
Average, nonmetals (excluding stone and sand and gravel)[1]	7.44	.10	7.54	12.46	.60	13.06	8.24	.18	8.42
Average, metals and nonmetals, (excluding stone and sand and gravel)[1]	7.25	.34	7.59	16.58	2.62	19.20	8.49	.65	9.14

W Withheld to avoid disclosing individual company confidential data.
[1]Includes unpublished data.

Table 5.—Crude ore and total material handled at surface and underground mines in 1976, by commodity

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
METALS				
Antimony	2.0	98.0	5.5	94.5
Bauxite	[1]100.0	W	[1]100.0	W
Beryllium	100.0	--	100.0	--
Copper	91.1	8.9	97.3	2.7
Gold:				
Lode	43.9	56.1	88.5	11.5
Placer	100.0	--	100.0	--
Iron ore	96.1	3.9	97.7	2.3
Lead	--	100.0	.1	99.9
Manganiferous ore	100.0	--	100.0	--
Mercury	98.5	1.5	99.8	.2
Molybdenum	58.7	41.3	76.0	24.0
Nickel	100.0	--	100.0	--
Platinum-group metals	100.0	--	100.0	--
Rare-earth metals	100.0	--	100.0	--
Silver	56.0	44.0	55.1	44.9
Tin	100.0	--	100.0	--
Titanium, ilmenite	100.0	--	100.0	--
Tungsten	12.2	87.8	8.7	91.3
Uranium	56.8	43.2	96.9	3.1
Vanadium	100.0	--	100.0	--
Zinc	.7	99.3	.9	99.1
Total metals	88.7	11.3	95.4	4.6
NONMETALS				
Abrasive stone	100.0	--	100.0	--
Aplite	100.0	--	100.0	--
Asbestos	[1]100.0	W	[1]100.0	W
Barite	[1]100.0	W	[1]100.0	W
Boron minerals	100.0	--	100.0	--
Clays	98.6	1.4	98.6	1.4
Diatomite	100.0	--	100.0	--
Emery	100.0	--	100.0	--
Feldspar	[1]100.0	W	[1]100.0	W
Fluorspar	4.0	96.0	4.4	95.6
Garnet	100.0	--	100.0	--
Graphite	100.0	--	100.0	--
Greensand marl	100.0	--	100.0	--
Gypsum	81.3	18.7	89.1	10.9
Iron oxide pigments (crude)	100.0	--	100.0	--
Kyanite	100.0	--	100.0	--
Lithium minerals	100.0	--	100.0	--
Magnesite	100.0	--	100.0	--
Mica (scrap)	100.0	--	100.0	--
Millstones	100.0	--	100.0	--
Olivine	100.0	--	100.0	--
Perlite	[1]100.0	W	[1]100.0	W
Phosphate rock	[1]100.0	W	[1]100.0	W
Potassium salts	--	100.0	--	100.0
Pumice	100.0	--	100.0	--
Salt	2.8	97.2	3.0	97.0
Sand and gravel	100.0	--	100.0	--
Sodium carbonate (natural)	--	100.0	--	100.0
Stone:				
Crushed and broken	96.2	3.8	96.2	3.8
Dimension	99.0	1.0	99.0	1.0
Talc, soapstone, pyrophyllite	92.0	8.0	97.7	2.3
Tripoli	46.6	53.4	50.9	49.1
Vermiculite	100.0	--	100.0	--
Wollastonite	--	100.0	--	100.0
Total nonmetals	96.1	3.9	96.3	3.7
Grand total	94.4	5.6	95.9	4.1

W Withheld to avoid disclosing individual company confidential data; included with "Surface."
[1]Includes underground; the Bureau of Mines is not at liberty to publish separately.

Table 6.—Crude ore and total material handled at surface and underground mines in 1976, by State

(Percent)

State	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Alabama	[1]100	W	[1]100	W
Alaska	100	--	100	--
Arizona	91	9	97	3
Arkansas	99	1	99	1
California	99	1	99	1
Colorado	69	31	72	28
Connecticut	100	--	100	--
Delaware	100	--	100	--
Florida	100	--	100	--
Georgia	98	2	98	2
Hawaii	100	--	100	--
Idaho	90	10	96	4
Illinois	97	3	97	3
Indiana	98	2	98	2
Iowa	98	2	98	2
Kansas	91	9	91	9
Kentucky	83	17	83	17
Louisiana	83	17	83	17
Maine	[1]100	W	[1]100	W
Maryland	[1]100	W	[1]100	W
Massachusetts	100	--	100	--
Michigan	95	5	96	4
Minnesota	100	--	100	--
Mississippi	100	--	100	--
Missouri	73	27	71	29
Montana	99	1	99	1
Nebraska	[1]100	W	[1]100	W
Nevada	99	1	99	1
New Hampshire	100	--	100	--
New Jersey	99	1	99	1
New Mexico	71	29	92	8
New York	92	8	92	8
North Carolina	100	--	100	--
North Dakota	100	--	100	--
Ohio	95	5	95	5
Oklahoma	97	3	97	3
Oregon	100	--	100	--
Pennsylvania	93	7	93	7
Rhode Island	100	--	100	--
South Carolina	100	--	100	--
South Dakota	86	14	85	15
Tennessee	89	11	89	11
Texas	100	--	100	--
Utah	97	3	98	2
Vermont	[1]100	W	[1]100	W
Virginia	95	5	93	7
Washington	99	1	99	1
West Virginia	83	17	83	17
Wisconsin	[1]100	W	[1]100	W
Wyoming	64	36	91	9
Total	94	6	96	4

W Withheld to avoid disclosing individual company confidential data; included with "Surface."
[1]Includes underground; the Bureau of Mines is not at liberty to publish separately.

Table 7.—Number of domestic metal and nonmetal mines in 1976, by commodity and magnitude of crude ore production[1]

Commodity	Total number of mines	Less than 1,000 tons	1,000 to 10,000 tons	10,000 to 100,000 tons	100,000 to 1,000,000 tons	1,000,000 to 10,000,000 tons	More than 10,000,000 tons
METALS							
Bauxite	14	1	--	7	6	--	--
Copper	45	4	1	2	7	21	10
Gold:							
Lode	51	34	5	7	4	1	--
Placer	37	14	10	9	2	2	--
Iron ore	65	--	8	10	19	23	5
Lead	37	18	5	2	7	5	--
Mercury	6	2	3	1	--	--	--
Silver	63	41	11	8	3	--	--
Titanium, ilmenite	7	--	--	--	1	6	--
Tungsten	43	34	6	2	1	--	--
Uranium	212	39	89	62	21	1	--
Zinc	31	--	2	7	21	1	--
Other[2]	13	1	1	3	5	1	2
Total metals	624	188	141	120	97	61	17
NONMETALS							
Abrasives[3]	14	2	6	5	1	--	--
Asbestos	4	--	1	--	2	1	--
Barite	37	--	12	24	1	--	--
Boron minerals	2	--	--	--	1	1	--
Clays	1,132	58	306	636	132	--	--
Diatomite	14	1	6	5	2	--	--
Feldspar	25	2	10	7	6	--	--
Fluorspar	8	--	3	3	2	--	--
Gypsum	68	1	7	20	40	--	--
Mica (scrap)	13	1	5	4	3	--	--
Perlite	12	--	5	5	2	--	--
Phosphate rock	51	2	7	6	15	16	5
Potassium salts	9	--	--	--	4	5	--
Pumice	192	11	103	70	8	--	--
Salt	19	--	2	2	6	9	--
Sand and gravel	7,599	190	1,406	3,839	2,103	59	2
Sodium carbonate (natural)	4	--	--	--	1	3	--
Stone:							
Crushed and broken	4,950	511	742	1,819	1,746	131	1
Dimension	431	215	183	33	--	--	--
Talc, soapstone, pyrophyllite	40	4	16	18	2	--	--
Other[4]	31	10	3	11	6	1	--
Total nonmetals	14,655	1,008	2,823	6,507	4,083	226	8
Grand total	15,279	1,196	2,964	6,627	4,180	287	25

[1]Excludes wells, ponds, or pumping operations.
[2]Antimony, beryllium, manganiferous ore, molybdenum, nickel, platinum-group metals, rare-earth metals, and vanadium.
[3]Abrasive stone, emery, garnet, and tripoli.
[4]Aplite, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, millstones, olivine, tube-mill liners, vermiculite, and wollastonite.

Table 8.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1976, in order of output of crude ore

Mine	State	Operator	Commodity	Mining method
		METALS		
Minntac	Minnesota	United States Steel Corp	Iron ore	Open pit.
Erie Commercial	do	Pickands Mather & Co	do	Do.
Sierrita	Arizona	Duval Sierrita Corp	Copper	Do.
Peter Mitchell	Minnesota	Reserve Mining Co	Iron ore	Do.
Utah Copper	Utah	Kennecott Copper Corp	Copper	Do.
Empire	Michigan	Cleveland-Cliffs Iron Co	Iron ore	Do.
Pima	Arizona	Cyprus Pima Mining Co.	Copper	Do.
Morenci	do	Phelps Dodge Corp	do	Do.
Climax	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Caving and open pit.
Berkeley Pit	Montana	The Anaconda Company	Copper	Open pit.
Tyrone	New Mexico	Phelps Dodge Corp	do	Do.
Pinto Valley	Arizona	Cities Service Co	do	Do.
San Manuel	do	Magma Copper Co	do	Caving.
Twin Buttes	do	Anamax Mining Co	do	Open pit.
Questa	New Mexico	Molybdenum Corp. of America.	Molybdenum	Do.
Tilden	Michigan	Cleveland-Cliffs Iron Co	Iron ore	Do.
Metcalf	Arizona	Phelps Dodge Corp	Copper	Do.
Ray Pit	do	Kennecott Copper Corp.	do	Do.
New Cornelia	do	Phelps Dodge Corp	do	Do.
Republic	Michigan	Cleveland-Cliffs Iron Co	Iron ore	Do.
Thunderbird	Minnesota	Oglebay Norton Co	do	Do.
Butler Project	do	Hanna Mining Co	do	Do.
Eagle Mountain	California	Kaiser Steel Corp	do	Do.
Yerington	Nevada	The Anaconda Company	Copper	Do.
Inspiration	Arizona	Inspiration Consolidated Copper Corp.	do	Do.
		NONMETALS		
Swift Creek	Florida	Occidental Chemical Corp.	Phosphate rock.	Open pit.
Kingsford	do	International Minerals & Chemical Corp.	do	Do.
Noralyn	do	do	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Calcite	Michigan	United States Steel Corp	Stone	Open quarry.
Haynsworth	Florida	American Cyanamid Co	Phosphate rock.	Open pit.
Clear Spring	do	International Minerals & Chemical Corp.	do	Do.
Rockland	do	United States Steel Corp	do	Do.
Payne Creek	do	Continental Oil Co	do	Do.
Ft. Green	do	do	do	Do.
Stoneport	Michigan	Presque Isle Corp	Stone	Open quarry.
Thornton	Illinois	General Dynamics Corp	do	Do.
Nichols	Florida	Mobil Oil Corp	Phosphate rock.	Open pit.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Feld	Texas	Texas Crushed Stone Co	Stone	Open quarry.
Lee Creek	North Carolina	Texasgulf Inc	Phosphate rock.	Open pit.
Tenoroc	Florida	Borden, Inc	do	Do.
Watson	do	Swift Agricultural Chemicals Corp.	do	Do.
Pennsuco	do	Maule Industries, Inc	Stone	Dredging.
Westvaco	Wyoming	FMC Corp	Sodium carbonate.	Artificial stopes.
International	New Mexico	International Minerals & Chemical Corp.	Potassium salts.	Open stopes.
Alpena	Michigan	Huron Portland Cement Co.	Stone	Open quarry.
Beckman	Texas	McDonough Bros., Inc	do	Do.
Cedarville	Michigan	United States Steel Corp	do	Do.
Peerless	Missouri	Missouri Lime Co	do	Open stopes.

[1]Brines and materials from wells excepted.

Table 9.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1976, in order of output of total materials handled

Mine	State	Operator	Commodity	Mining method
		METALS		
Utah Copper	Utah	Kennecott Copper Corp	Copper	Open pit.
Tyrone	New Mexico	Phelps Dodge Corp	do	Do.
Twin Buttes	Arizona	Anamax Mining Co	do	Do.
Sierrita	do	Duval Sierrita Corp	do	Do.
Minntac	Minnesota	United States Steel Corp	Iron ore	Do.
Mitchell Pit	do	Reserve Mining Co	do	Do.
Berkeley Pit	Montana	The Anaconda Company	Copper	Do.
Pima	Arizona	Cyprus Pima Mining Co	do	Do.
Erie Commercial	Minnesota	Pickands Mather & Co	Iron ore	Do.
Morenci	Arizona	Phelps Dodge Corp	Copper	Do.
Pinto Valley	do	Cities Service Co	do	Do.
Eagle Mountain	California	Kaiser Steel Corp	Iron ore	Do.
Shirley Basin	Wyoming	Utah International Inc	Uranium	Do.
Ray Pit	Arizona	Kennecott Copper Corp	Copper	Do.
Metcalf	do	Phelps Dodge Corp	do	Do.
Jackpile-Paquate	New Mexico	The Anaconda Company	Uranium	Do.
Empire	Michigan	Cleveland-Cliffs Iron Co	Iron ore	Do.
Climax	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Caving and open pit.
Highland	Wyoming	Exxon Corp	Uranium	Open pit.
Chino	New Mexico	Kennecott Copper Corp	Copper	Do.
Sacaton	Arizona	ASARCO, Inc	do	Do.
Questa	New Mexico	Molybdenum Corp. of America.	Molybdenum	Do.
W Gas Hill	Wyoming	Union Carbide Mining & Metals Corp.	Uranium	Open stopes.
Bagdad	Arizona	Cyprus Bagdad Copper Co.	Copper	Open pit.
New Cornelia	do	Phelps Dodge Corp	do	Do.
		NONMETALS		
Kingsford	Florida	International Minerals & Chemical Corp.	Phosphate rock.	Open pit.
Noralyn	do	do	do	Do.
Lee Creek	North Carolina	Texasgulf Inc	do	Do.
Rockland	Florida	United States Steel Corp	do	Do.
Haynsworth	do	American Cyanamid Co	do	Do.
Clear Spring	do	International Minerals & Chemical Corp.	do	Do.
Swift Creek	do	Occidental Chemical Co	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Nichols	do	Mobil Oil Corp	do	Do.
Tampa Agricultural Chemical Operations.	do	Gardinier, Inc	do	Do.
Boron	California	U.S. Borax & Chemical Corp.	Boron	Do.
Watson	Florida	Swift Agricultural Chemicals Corp.	Phosphate rock.	Do.
Silver City	do	do	do	Do.
Calcite	Michigan	United States Steel Corp	Stone	Open quarry.
Payne Creek	Florida	Continental Oil Co	Phosphate rock.	Open pit.
Ft. Green	do	do	do	Do.
Conda	Idaho	J. R. Simplot Co	do	Do.
Westvaco	Wyoming	FMC Corp	Sodium carbonate.	Artificial stopes.
Wooley Valley	Idaho	Stauffer Chemical Co	Phosphate rock.	Open pit.
Gay	do	J. R. Simplot Co	do	Do.
Stoneport	Michigan	Presque Isle Corp	Stone	Open quarry.
Thornton	Illinois	General Dynamics Corp	do	Do.
Lompoc	California	Johns Mansville Corp	Diatomite	Open pit.
Feld	Texas	Texas Crushed Stone Co	Stone	Open quarry.

[1]Brines and materials from wells excepted.

Table 10.—Ore treated or sold per unit of marketable product at surface and underground mines in the United States in 1976, by commodity

Commodity	Unit of marketable product	Surface: Ore treated (thousand short tons)	Surface: Marketable product (units)	Surface: Ratio of units of ore to units of marketable product	Underground: Ore treated (thousand short tons)	Underground: Marketable product (units)	Underground: Ratio of units of ore to units of marketable product	Total[1]: Ore treated (thousand short tons)	Total[1]: Marketable product (units)	Total[1]: Ratio of units of ore to units of marketable product
METALS										
Bauxite	thousand long tons	3,540	1,950	1.8:1	W	W	W	3,540	1,950	1.8:1
Copper	thousand short tons	256,000	1,360	187.9:1	28,800	221	130.2:1	285,000	1,580	179.8:1
Gold:										
Lode	thousand troy ounces	1,520	263	5.8:1	1,720	352	4.9:1	3,240	614	5.3:1
Placer	do	4,990	28	180.8:1	1	--	--	4,990	28	180.8:1
Iron ore	thousand long tons	233,000	71,000	3.3:1	9,770	5,380	1.8:1	243,000	76,400	3.2:1
Lead	thousand short tons	1	(2)	20.2:1	9,950	547	18.2:1	9,950	547	18.2:1
Mercury	thousand flasks	184	23	8.0:1	W	W	W	184	23	8.0:1
Silver	thousand troy ounces	985	266	3.7:1	827	10,600	0.1:1	1,810	10,800	0.2:1
Titanium, ilmenite	thousand short tons	36,700	618	59.3:1	--	--	--	36,700	618	59.3:1
Uranium	do	5,080	6	787.8:1	4,190	6	682.9:1	9,260	13	736.7:1
Zinc	do	60	--	--	8,360	347	24.1:1	8,420	347	24.3:1
NONMETALS										
Asbestos	do	2,110	114	18.6:1	W	W	W	2,110	114	18.6:1
Barite	do	1,270	1,230	1.0:1	W	W	W	1,270	1,230	1.0:1
Clays	do	47,500	47,500	1.0:1	692	692	1.0:1	48,200	48,200	1.0:1
Diatomite	do	852	631	1.4:1	--	--	--	852	631	1.4:1
Feldspar	do	1,340	718	1.9:1	W	W	W	1,340	718	1.9:1
Fluorspar	do	26	22	1.2:1	554	167	3.3:1	581	188	3.1:1
Gypsum	do	10,100	9,540	1.1:1	2,310	2,440	1.0:1	12,400	12,000	1.0:1
Mica (scrap)	do	591	95	6.2:1	--	--	--	591	95	6.2:1
Perlite	do	592	549	1.1:1	W	W	W	592	549	1.1:1
Phosphate rock	do	169,000	49,000	3.4:1	W	W	W	169,000	49,000	3.4:1
Potassium salts	do	--	--	--	17,300	2,080	8.3:1	17,300	2,080	8.3:1
Pumice	do	4,140	4,130	1.0:1	--	--	--	4,140	4,130	1.0:1
Salt	do	429	233	1.8:1	15,500	15,300	1.0:1	15,900	15,600	1.0:1
Sand and gravel	do	885,000	885,000	1.0:1	--	--	--	885,000	885,000	1.0:1
Sodium carbonate (natural)	do	--	--	--	9,660	4,940	2.0:1	9,660	4,940	2.0:1
S⁺ɔne:										
Crushed and broken	do	869,000	865,000	1.0:1	34,300	34,300	1.0:1	903,000	900,000	1.0:1
Dimension	do	[e]3,050	1,390	2.0:1	13	13	1.0:1	3,060	1,400	2.2:1
Talc, soapstone, pyrophyllite	do	1,030	1,020	1.0:1	78	78	1.0:1	1,110	1,090	1.0:1

[e]Estimate. W Withheld to avoid disclosing individual company confidential data.
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 11.—Material handled per unit of marketable product at surface and underground mines in the United States in 1976, by commodity

Commodity	Unit of marketable product	Surface: Total material handled[2] (thousand short tons)	Surface: Marketable product (units)	Surface: Ratio of units of material handled to units of marketable product[3]	Underground: Total material handled[2] (thousand short tons)	Underground: Marketable product (units)	Underground: Ratio of units of material handled to units of marketable product[3]	Total[1]: Total material handled[2] (thousand short tons)	Total[1]: Marketable product (units)	Total[1]: Ratio of units of material handled to units of marketable product[3]
METALS										
Bauxite	thousand long tons	18,000	1,950	9.3:1	W	W	W	18,000	1,950	9.3:1
Copper	thousand short tons	942,000	1,360	649.9:1	26,400	221	114.2:1	969,000	1,580	575.1:1
Gold:										
Lode	thousand troy ounces	14,700	263	25.9:1	1,910	352	4.9:1	16,600	614	13.9:1
Placer	do	5,490	28	183.7:1	1	--	--	5,490	28	183.8:1
Iron ore	thousand long tons	485,000	71,000	6.6:1	11,400	5,380	1.9:1	496,000	76,400	6.3:1
Lead	thousand short tons	11	([4])	30.0:1	12,300	547	19.5:1	12,300	547	19.5:1
Mercury	thousand flasks	738	23	32.1:1	W	W	W	738	23	32.1:1
Silver	thousand troy ounces	1,340	266	3.7:1	1,090	10,600	0.1:1	2,430	10,800	0.2:1
Titanium, ilmenite	thousand short tons	45,200	618	73.1:1	--	--	--	45,200	618	73.1:1
Uranium	do	258,000	6	17,803.4:1	8,110	6	1,057.9:1	266,000	13	9,641.1:1
Zinc	do	113	--	--	12,000	347	27.1:1	12,100	347	27.3:1
NONMETALS										
Asbestos	do	2,290	114	19.7:1	W	W	W	2,290	114	19.7:1
Barite	do	2,110	1,230	1.7:1	W	W	W	2,110	1,230	1.7:1
Clays	do	[e]88,800	47,500	1.9:1	[e]702	692	1.0:1	89,500	48,200	1.9:1
Diatomite	do	7,330	631	11.6:1	--	--	--	7,330	631	11.6:1
Feldspar	do	1,510	718	2.1:1	W	W	W	1,510	718	2.1:1
Fluorspar	do	29	22	1.1:1	631	167	3.5:1	660	188	3.2:1
Gypsum	do	19,000	9,540	1.1:1	2,310	2,440	1.0:1	21,300	12,000	1.1:1
Mica (scrap)	do	997	95	10.4:1	--	--	--	997	95	10.4:1
Perlite	do	728	549	1.3:1	W	W	W	728	549	1.3:1
Phosphate rock	do	411,000	49,000	8.1:1	W	W	W	411,000	49,000	8.1:1
Potassium salts	do	--	--	--	17,700	2,080	8.4:1	17,700	2,080	8.4:1
Pumice	do	4,890	4,130	1.2:1	--	--	--	4,890	4,130	1.2:1
Salt	do	492	233	2.1:1	15,700	15,300	1.0:1	16,200	15,600	1.0:1
Sand and gravel	do	885,000	885,000	1.0:1	--	--	--	885,000	885,000	1.0:1
Sodium carbonate (natural)	do	--	--	--	14,300	4,940	1.9:1	14,300	4,940	1.9:1
Stone:										
Crushed and broken	do	[e]935,000	865,000	1.1:1	[e]34,600	34,300	1.0:1	970,000	900,000	1.1:1
Dimension	do	[e]4,660	1,390	3.4:1	13	13	1.0:1	4,670	1,400	3.3:1
Talc, soapstone, pyrophyllite	do	3,430	1,020	3.0:1	80	78	1.0:1	3,510	1,090	2.9:1

[e]Estimate. W Withheld to avoid disclosing individual company confidential data.
[1]Data may not add to totals shown because of independent rounding.
[2]Includes material from development and exploration activities.
[3]Material from development and exploration activities is excluded from the ratio calculation.
[4]Less than 1/2 unit.

Table 12.—Mining methods used in open pit mining in 1976, by commodity

(Percent)

Commodity	Total material handled: Preceded by drilling and blasting	Total material handled: Not preceded by drilling and blasting[1]
METALS		
Antimony	100	--
Bauxite	91	9
Copper	92	8
Gold:		
Lode	99	1
Placer	--	100
Iron ore	87	13
Lead	67	33
Manganiferous ore	100	--
Mercury	7	93
Molybdenum	100	--
Nickel	16	84
Platinum-group metals	--	100
Rare-earth metals	100	--
Silver	5	95
Tin	--	100
Titanium, ilmenite	5	95
Tungsten	69	31
Uranium	41	59
Vanadium	50	50
Zinc	100	--
NONMETALS		
Abrasive stone	100	--
Aplite	23	77
Asbestos	91	9
Barite	22	78
Boron minerals	100	--
Clays	--	100
Diatomite	--	100
Emery	100	--
Feldspar	87	13
Fluorspar	83	17
Garnet	99	1
Graphite	100	--
Greensand marl	--	100
Gypsum	85	15
Iron oxide pigments (crude)	--	100
Kyanite	59	41
Lithium minerals	100	--
Magnesite	100	--
Mica (scrap)	10	90
Millstones	58	42
Olivine	53	47
Perlite	8	92
Phosphate rock	12	88
Pumice	7	93
Salt	100	--
Sand and gravel	--	100
Stone:		
Crushed and broken	98	2
Dimension	--	100
Talc, soapstone, pyrophyllite	89	11
Tripoli	100	--
Vermiculite	100	--
Total	58	42

[1]Includes drilling or cutting without blasting, dredging, mechanical excavation and nonfloat washing, and other surface mining methods.

Table 13.—Exploration and development activity in the United States in 1976, by method

Method	Metals		Nonmetals		Total[1]	
	Feet	Percent of total[2]	Feet	Percent of total[2]	Feet	Percent of total[2]
DEVELOPMENT						
Shaft and winze sinking	21,400	2.1	15,300	2.7	36,700	2.3
Raising	144,000	14.1	2,820	.5	147,000	9.3
Drifting, crosscutting, or tunneling	853,000	83.7	544,000	96.7	1,400,000	88.3
Total[1]	1,020,000	100.0	562,000	100.0	1,580,000	100.0
EXPLORATION						
Diamond drilling	1,680,000	12.3	351,000	38.8	2,030,000	14.0
Churn drilling	36,400	.3	--	--	36,400	.3
Rotary drilling	7,710,000	56.6	540,000	59.7	8,250,000	56.8
Percussion drilling	3,790,000	27.8	5,820	.6	3,800,000	26.1
Other drilling	352,000	2.5	3,380	.4	355,000	2.3
Trenching	62,100	.5	4,790	.5	66,900	.5
Total[1]	13,600,000	100.0	905,000	100.0	14,500,000	100.0
Grand total[1]	14,600,000	XX	1,470,000	XX	16,100,000	XX

XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.
[2]Based on unrounded footage.

Table 14.—Exploration and development in 1976, by method and selected metals and nonmetals

(Feet)

Commodity	Development: Shaft and winze sinking	Development: Raising	Development: Drifting, cross-cutting, or tunneling	Development: Total[1]	Exploration: Diamond drilling	Exploration: Churn drilling	Exploration: Rotary drilling	Exploration: Percussion drilling	Exploration: Other drilling	Exploration: Trenching	Exploration: Total[1]
METALS											
Bauxite	--	--	--	--	--	--	31,500	--	64,900	--	96,400
Copper	10,200	64,700	116,000	191,000	561,000	515	75,900	30,500	206	4,390	673,000
Gold	1,130	12,700	47,800	61,600	154,000	1,320	105,000	2,790,000	7,000	36,000	3,090,000
Iron ore	--	329	66,000	66,300	46,500	--	14,200	28,300	1,570	--	90,600
Lead	397	5,020	56,700	62,100	198,000	34,600	--	22,200	99,200	176	354,000
Molybdenum	--	W	W	W	137,000	--	16,400	--	--	--	153,000
Nickel	--	--	--	--	11,100	--	--	--	--	--	11,100
Silver	370	6,040	16,300	22,700	83,700	--	5,920	25,300	3,100	7,850	126,000
Tungsten	75	1,710	21,400	23,100	--	--	--	1,280	--	150	1,430
Uranium	6,540	30,200	392,000	429,000	143,000	--	7,390,000	798,000	144,000	10,300	8,480,000
Zinc	2,680	15,200	85,700	104,000	329,000	--	61,200	97,900	378	260	489,000
Other[2]	--	8,460	50,800	59,300	18,300	--	17,100	--	30,900	3,500	69,800
Total[1]	21,400	144,000	853,000	1,020,000	1,680,000	36,400	7,710,000	3,790,000	352,000	62,100	13,600,000
NONMETALS											
Barite	W	W	--	W	--	--	26,000	3,050	--	3,500	32,600
Boron minerals	--	--	--	--	2,200	--	38,900	--	--	--	41,100
Clays	--	--	--	--	126	--	5,560	--	783	--	6,470
Fluorspar	--	1,550	4,100	5,650	305,000	--	--	--	2,590	--	308,000
Gypsum	305	--	365	670	--	--	--	--	--	--	
Phosphate rock	--	110	7,100	7,210	5,870	--	342,000	--	--	1,100	348,000
Sodium carbonate (natural)	--	--	W	W	6,830	--	109,000	--	--	--	116,000
Other[3]	15,000	1,162	532,000	548,000	31,400		18,800	2,770		185	53,200
Total[1]	15,300	2,820	544,000	562,000	351,000	--	540,000	5,820	3,380	4,790	905,000
Grand total[1]	36,700	147,000	1,400,000	1,580,000	2,030,000	36,400	8,250,000	3,800,000	355,000	66,900	14,500,000

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.
[2]Antimony, beryllium, columbium and tantalum, rare-earth metals, tin, and titanium (ilmenite).
[3]Asbestos, mica (scrap), potassium salts, salt, stone (crushed and broken), stone (dimension), talc, soapstone, pyrophyllite, tripoli, and wollastonite.

Table 15.—Exploration and development in 1976, by method and State

(Feet)

State	Development				Exploration						
	Shaft and winze sinking	Raising	Drifting, cross-cutting, or tunneling	Total[1]	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other drilling	Trenching	Total[1]
Alaska	--	--	24	24	27,800	126	--	580	70	7,760	36,300
Arizona	271	64,200	100,000	165,000	162,000	--	47,200	5,800	--	7,020	222,000
Arkansas	--	--	--	--	610	--	31,500	--	--	--	32,100
California	15,000	3,480	7,030	25,500	4,980	1,020	55,400	35	96	924	62,400
Colorado	999	19,200	104,000	124,000	152,000	--	1,340,000	138,000	4,210	535	1,630,000
Florida	--	--	--	--	--	--	272,000	--	--	--	272,000
Georgia	--	--	--	--	1,210	--	8,300	--	--	--	9,510
Idaho	791	6,970	32,000	39,700	56,600	--	18,700	1,700	1,320	610	79,000
Illinois	--	1,400	4,100	5,500	152,000	--	--	--	--	--	152,000
Kentucky	--	--	--	--	85,500	--	--	--	--	--	85,500
Maine	--	--	W	W	8,670	--	--	--	--	--	8,670
Michigan	305	--	13,000	13,300	81,100	--	2,940	--	--	--	84,000
Minnesota	--	--	--	--	31,300	--	1,360	229	783	--	33,700
Missouri	--	359	80,100	80,500	188,000	34,600	27,300	39,500	99,200	1,400	390,000
Montana	35	450	10,100	10,500	66,300	515	312,000	2,800	--	630	383,000
Nevada	2,790	1,140	24,100	28,000	63,600	180	52,400	41,600	5,540	31,700	195,000
New Mexico	4,590	15,300	298,000	318,000	249,000	--	1,570,000	640,000	136,000	4,900	2,600,000
New York	--	7,260	36,400	43,600	83,400	--	--	--	--	--	83,400
Oregon	--	170	2,550	2,720	14,700	--	9,350	12,200	4,000	1,000	41,300
South Dakota	W	W	W	W	73,900	--	713,000	2,760,000	--	--	3,540,000
Tennessee	2,160	2,690	31,200	36,000	266,000	--	51,000	88,500	--	--	405,000
Texas	--	--	--	--	--	--	122,000	--	--	--	122,000
Utah	8,470	8,100	40,300	56,900	62,300	--	411,000	55,600	6,090	10,300	546,000
Wisconsin	--	--	--	--	27,300	--	18,500	--	--	--	45,800
Wyoming	1,150	3,410	557,000	562,000	39,300	--	2,850,000	2,000	--	--	2,890,000
Undistributed[2]	164	13,000	56,000	69,200	136,000	--	340,000	9,980	97,300	125	584,000
Total[1]	36,700	147,000	1,400,000	1,580,000	2,030,000	36,400	8,250,000	3,800,000	355,000	66,900	14,500,000

W Withheld to avoid disclosing individual company confidential data; included in "Undistributed."
[1]Data may not add to totals shown because of independent rounding.
[2]Alabama, Kansas, North Carolina, Oklahoma, Pennsylvania, South Carolina, Vermont, Virginia, Washington, and items indicated by symbol W.

Table 16.—Total material (ore and waste) produced by mine development in the United States in 1976, by commodity and State

(Thousand short tons)

	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Stripping	Total[1]
COMMODITY					
METALS					
Copper	77	184	945	57,100	58,300
Gold:					
Lode	10	44	154	7,860	8,070
Placer	--	--	(2)	414	414
Iron ore	--	1	1,160	13,200	14,400
Lead	4	13	1,610	10	1,640
Silver	1	25	79	359	464
Tungsten	1	4	295	1	301
Uranium	117	96	1,440	144,000	145,000
Zinc	409	296	1,850	66	2,620
Other[3]	--	34	546	223	803
Total metals[1]	620	699	8,090	223,000	232,000
NONMETALS					
Fluorspar	--	10	34	5	49
Gypsum	3	--	3	8,680	8,690
Phosphate rock	--	1	23	12,100	12,100
Potassium salts	--	3	163	--	166
Talc, soapstone, pyrophyllite	--	--	1	364	365
Other[4]	3	(2)	4,660	78	4,745
Total nonmetals[1]	6	15	4,890	21,200	26,100
Grand total[1]	626	713	13,000	244,000	258,000
STATE					
Alaska	--	--	(2)	406	406
Arizona	1	180	722	1,730	2,630
Arkansas	--	--	--	1,370	1,370
California	3	6	169	2,050	2,220
Colorado	7	69	814	11	901
Idaho	11	28	194	12,400	12,700
Illinois	--	10	34	5	49
Iowa	--	--	--	W	W
Maine	--	--	61	--	61
Michigan	3	--	115	500	618
Minnesota	--	--	--	11,800	11,800
Missouri	--	2	2,470	--	2,480
Montana	(2)	2	35	2	38
Nevada	44	8	236	9,250	9,530
New Mexico	93	37	1,140	55,500	56,800
New York	--	9	108	16	133
North Carolina	--	--	--	W	W
Ohio	--	--	--	W	W
Oklahoma	--	--	--	W	W
Oregon	--	(2)	10	6	16
Pennsylvania	--	W	W	W	W
South Dakota	W	W	W	--	W
Tennessee	28	6	826	13	873
Texas	--	--	--	47,100	47,100
Utah	425	299	1,040	137	1,900
Vermont	--	--	W	--	W
Virginia	--	W	W	W	W
Washington	--	--	(2)	6	6
Wisconsin	--	--	--	W	W
Wyoming	10	11	4,810	98,200	103,000
Undistributed	1	45	252	2,140	2,440
Total[1]	626	713	13,000	244,000	258,000

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Antimony, beryllium, manganiferous ore, molybdenum, tin, and titanium (ilmenite).
[4]Asbestos, barite, garnet, mica (scrap), millstones, salt, sodium carbonate, and tripoli.

Table 17.—U.S. industrial consumption of explosives

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total mineral industry	Other	Total industrial
1972	1,212,585	430,686	493,677	2,136,948	532,841	2,669,789
1973	1,177,062	495,879	643,292	2,316,233	438,713	2,754,946
1974	1,186,614	465,490	551,380	2,203,484	558,806	2,762,290
1975	1,652,251	449,271	493,125	2,594,647	524,380	3,119,027
1976	1,798,873	488,653	493,656	2,781,182	547,347	3,328,529

Table 18.—U.S. consumption of explosives in the minerals industry

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total
PERMISSIBLE EXPLOSIVES				
1972	42,232	99	865	43,196
1973	39,307	115	957	40,379
1974	38,332	192	1,237	39,761
1975	41,996	241	1,083	43,320
1976	41,123	204	1,090	42,417
OTHER HIGH EXPLOSIVES				
1972	16,297	27,648	100,600	144,545
1973	20,198	28,295	107,675	156,168
1974	26,301	27,733	99,364	153,398
1975	36,875	25,118	74,796	136,789
1976	34,521	24,265	65,891	124,677
CYLINDRICALLY PACKED BLASTING AGENTS				
1972	201,820	7,542	30,064	239,426
1973	222,797	6,265	32,228	261,290
1974	249,843	5,414	32,797	288,054
1975	286,608	4,845	28,551	320,004
1976	269,778	3,471	65,922	339,171
PACKAGED AND BULK WATER GELS AND SLURRIES				
1972	9,212	156,618	41,305	207,135
1973	11,622	173,530	54,154	239,306
1974	22,204	160,198	75,837	258,239
1975	24,118	181,809	73,872	279,799
1976	30,871	205,429	74,176	310,476
OTHER PROCESSED BLASTING AGENTS AND UNPROCESSED AMMONIUM NITRATE				
1972	943,024	238,779	320,843	1,502,646
1973	883,138	287,674	448,278	1,619,090
1974	849,934	271,953	342,145	1,464,032
1975	1,262,654	237,258	314,823	1,814,735
1976	1,422,580	255,284	286,577	1,964,441
TOTAL EXPLOSIVES				
1972	1,212,585	430,686	493,677	2,136,948
1973	1,177,062	495,879	643,292	2,316,233
1974	1,186,614	465,490	551,380	2,203,484
1975	1,652,251	449,271	493,125	2,594,647
1976	1,798,873	488,653	493,656	2,781,182

Statistical Summary

By Staff, Office of Technical Data Services

This chapter summarizes data on crude mineral production for the United States, its island possessions, and the Commonwealth of Puerto Rico. Included also are tables that show the principal mineral commodities exported from and imported into the United States and that compare world and U.S. mineral production. The detailed data from which these tables were derived are contained in the individual commodity chapters of volume I and in the State chapters of volume II of this edition of the Minerals Yearbook.

Although crude mineral production may be measured at any of several stages of extraction and processing, the stage of measurement used in this chapter is what is normally termed "mine output." It usually refers to minerals or ores in the form in which they are first extracted from the ground, but customarily includes the production of auxiliary processing at or near the mines.

Because of inadequacies in the statistics available, some series deviate from the foregoing definition. In the cases of gold, silver, copper, lead, zinc, and tin, the quantities are recorded on a mine basis (as the recoverable content of ore sold or treated). However, the values assigned to these quantities are based on the average selling price of refined metal, not on the mine value. Mercury is measured as recovered metal and valued at the average New York price for the metal.

The weight or volume units shown are those customarily used in the particular industries producing the commodities. Values shown are in current dollars, with no adjustment made to compensate for changes in the purchasing power of the dollar.

Table 1.—Value of crude mineral production[1] in the United States, by mineral group

(Million dollars)

Year	Mineral fuels	Nonmetals except fuels	Metals	Total
1972	22,061	6,482	3,642	32,185
1973	25,012	7,413	4,362	36,787
1974	40,937	r8,639	r5,501	r55,077
1975r	47,559	9,516	5,191	62,266
1976	52,545	10,547	6,086	69,178

rRevised.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Table 2.—Mineral production[1] in the United States

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
MINERAL FUELS								
Asphalt and related bitumens, native: Bituminous limestone, sandstone, gilsonite ---- short tons	2,088,657	$8,464	2,021,165	$16,666	1,901,715	r$17,838	2,011,500	$17,647
Carbon dioxide, natural ---- thousand cubic feet	1,134,986	259	966,118	237	1,070,024	279	1,356,834	298
Coal:								
Bituminous and lignite[2] ---- thousand short tons	591,738	5,049,612	603,406	9,502,347	648,438	12,472,486	678,685	13,189,481
Pennsylvania anthracite ---- do	6,830	90,260	6,617	144,695	6,203	198,481	6,228	209,234
Helium:								
Crude ---- million cubic feet	2,558	30,696	184	2,208	334	4,008	585	7,020
High-purity ---- do	647	16,121	699	18,105	745	19,915	754	18,928
Natural gas ---- do	22,647,549	4,894,072	21,600,522	6,573,402	20,108,661	8,945,062	19,952,438	11,571,776
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	187,390	668,784	168,152	1,107,158	151,872	878,698	149,679	985,442
LP gases ---- do	447,033	1,188,289	447,946	1,980,769	444,086	1,893,890	437,366	2,298,647
Peat ---- thousand short tons	621	7,547	706	10,989	746	12,294	947	17,096
Petroleum (crude) ---- thousand 42-gallon barrels	3,360,903	13,057,905	3,202,585	21,580,549	3,056,779	23,116,059	2,976,180	24,229,540
Total mineral fuels	XX	25,012,000	XX	40,937,000	XX	r47,559,000	XX	52,545,000
NONMETALS (EXCEPT FUELS)								
Abrasive stones[3] ---- short tons	3,466	667	3,134	717	2,953	1,060	2,696	1,404
Asbestos ---- do	150,036	16,288	109,091	13,393	98,654	14,220	114,842	23,693
Barite ---- thousand short tons	1,104	16,688	1,106	16,822	r1,318	r21,200	1,234	28,689
Boron minerals ---- do	1,225	113,648	1,185	128,306	1,172	158,772	1,246	184,852
Bromine ---- thousand pounds	418,250	67,131	432,094	117,715	407,163	113,126	439,538	107,653
Calcium chloride ---- short tons	609,300	17,581	739,100	24,552	594,400	29,047	648,979	32,889
Cement:								
Portland ---- thousand short tons	82,718	1,810,292	75,983	1,992,695	65,215	2,015,625	69,163	2,330,402
Masonry ---- do	4,057	119,547	3,371	111,106	2,868	111,801	3,267	139,564
Clays ---- do	64,351	354,058	60,796	422,542	49,047	424,556	52,389	528,745
Diatomite ---- short tons	608,906	36,083	664,303	50,693	573,000	45,812	631,000	54,982
Emery ---- do	2,884	W	W	W	3,487	W	W	W
Feldspar ---- do	791,900	12,830	r762,723	r11,396	r669,898	r11,728	739,684	17,531
Fluorspar ---- do	248,601	17,381	201,116	14,297	139,913	10,888	188,270	17,927
Garnet (abrasive) ---- do	22,772	2,381	24,684	2,550	17,204	1,690	24,565	2,740
Gem stones[e] ----	NA	2,739	NA	4,583	NA	13,900	NA	8,907
Gypsum ---- thousand short tons	13,558	56,650	11,999	52,894	9,751	44,654	11,980	59,888
Lime ---- do	21,090	365,849	21,606	473,685	19,133	523,805	20,229	609,010
Magnesium compounds from seawater and brine (except for metal) ---- short tons, MgO equivalent	853,907	77,733	907,492	96,742	W	W	W	W

Mica:								
Scrap ---- thousand short tons	177	6,082	137	5,475	135	5,219	127	5,686
Sheet ---- pounds	30,000	15	20,000	10	5,000	3	5,000	3
Perlite ---- short tons	543,683	5,591	555,000	7,024	512,000	7,282	553,000	9,397
Phosphate rock ---- thousand short tons	42,137	238,667	45,686	501,429	48,816	1,122,184	49,241	949,365
Potassium salts ---- thousand short tons, K_2O equivalent	2,603	112,613	2,552	159,148	2,501	223,098	2,500	202,635
Pumice ---- thousand short tons	3,937	8,881	3,937	9,121	3,892	11,203	4,134	10,466
Pyrites ---- thousand long tons	559	4,961	424	4,238	625	4,776	750	8,213
Salt ---- thousand short tons	43,910	306,103	46,536	360,763	41,030	368,063	44,191	430,959
Sand and gravel ---- do	983,629	1,359,370	904,646	1,421,237	789,436	1,416,346	885,156	1,774,030
Sodium carbonate (natural) ---- do	3,722	94,385	4,059	137,486	4,328	182,620	5,216	259,253
Sodium sulfate (natural) ---- do	672	11,597	684	16,411	667	27,667	663	32,655
Stone[4] ---- do	1,060,124	1,990,463	1,043,542	2,186,155	r901,393	r2,120,286	901,660	2,221,000
Sulfur, Frasch process ---- thousand long tons	7,438	138,578	7,898	241,066	6,077	304,843	5,860	299,999
Talc, soapstone, pyrophyllite ---- short tons	1,246,534	9,144	1,289,462	9,569	r964,609	r8,929	1,092,433	9,902
Tripoli ---- do	101,519	930	85,121	623	80,562	565	124,281	776
Vermiculite ---- thousand short tons	365	9,464	341	10,120	330	13,761	304	14,032
Value of items that cannot be disclosed: Aplite, natural and slag cement (1973), graphite, iodine, kyanite, lithium minerals, magnesite, greensand marl, olivine, staurolite, wollastonite, and values of nonmetal items indicated by W	XX	28,926	XX	34,125	XX	157,180	XX	169,491
Total nonmetals	XX	7,413,000	XX	r8,639,000	XX	r9,516,000	XX	10,547,000
METALS								
Antimony ore and concentrate ---- short tons, antimony content	545	688	661	2,040	886	2,131	283	600
Bauxite ---- thousand long tons, dried equivalent	1,879	26,635	1,949	25,663	1,772	25,083	1,958	26,645
Copper (recoverable content of ores, etc.) ---- short tons	1,717,940	2,044,346	1,597,002	2,468,964	1,413,366	1,814,763	1,605,586	2,234,975
Gold (recoverable content of ores, etc.) ---- troy ounces	1,175,750	115,000	1,126,886	180,009	1,052,252	169,928	1,048,037	131,340
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	90,654	1,163,710	84,985	1,388,447	75,695	1,620,599	76,697	1,860,102
Lead (recoverable content of ores, etc.) ---- short tons	603,024	196,465	663,870	298,742	621,464	267,230	609,546	281,610
Manganese ore (35% or more Mn) ---- short tons, gross weight	239	W	--	--	--	--	--	--
Manganiferous ore (5% to 35% Mn) ---- do	203,055	W	272,908	2,323	r159,225	r1,413	256,633	2,260
Mercury ---- 76-pound flasks	2,171	621	2,189	617	7,366	1,165	23,133	2,806
Molybdenum (content of concentrate) ---- thousand pounds	135,097	r217,721	118,163	234,658	105,170	259,328	114,527	333,494
Nickel (content of ore and concentrate) ---- short tons	18,272	W	16,618	W	16,987	W	16,469	W
Rare-earth metal concentrates ---- do	31,273	13,780	35,218	15,966	W	W	W	W
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	37,484	95,883	33,762	159,018	34,938	154,424	34,328	149,328
Tin ---- long tons	W	W	W	W	W	W	W	W
Titanium concentrate:								
Ilmenite ---- short tons, gross weight	804,355	20,128	755,338	22,715	702,252	26,946	617,896	27,578
Rutile ---- do	9,045	1,212	6,446	996	W	W	W	W
Tungsten ore and concentrate ---- thousand pounds contained W	7,059	19,154	7,836	37,413	5,490	29,090	5,869	37,266

Table 2.—Mineral production[1] in the United States —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
METALS —Continued								
Uranium (recoverable content of U_3O_8) thousand pounds	25,803	$167,718	23,227	r$192,560	r22,936	r$276,102	25,146	$404,830
Vanadium (recoverable in ore and concentrate) short tons	4,377	26,611	4,870	38,266	4,743	49,329	7,376	81,279
Zinc (recoverable content of ores, etc.) do	478,850	197,861	499,872	358,908	469,355	366,097	484,513	358,541
Value of items that cannot be disclosed: Beryllium, magnesium chloride for magnesium metal, manganiferous residuum, platinum- group metals (crude), zircon concentrate, and values indicated by W	XX	54,004	XX	r73,828	XX	127,459	XX	153,452
Total metals	XX	4,362,000	XX	r5,501,000	XX	r5,191,000	XX	6,086,000
Grand total	XX	36,787,000	XX	r55,077,000	XX	r62,266,000	XX	69,178,000

e Estimate. r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data; included with "Value of items that cannot be disclosed." XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Includes a small quantity of anthracite mined in States other than Pennsylvania.

[3] Grindstones, pulpstones, grinding pebbles, sharpening stones, and tube mill liners.

[4] Excludes abrasive stone, bituminous limestone, bituminous sandstone, and soapstone, all included elsewhere in table.

Table 3.—Minerals produced in the United States and principal producing States in 1976

Mineral	Principal producing States, in order of quantity	Other producing States
Antimony ore and concentrate	Mont. and Idaho.	
Aplite	Va.	
Asbestos	Calif., Vt., Ariz., N.C.	
Asphalt (native)	Tex., Utah, Ala., Mo.	
Barite	Nev., Mo., Ark., Ga	Idaho, Ill., Mont., Tenn.
Bauxite	Ark., Ala., Ga.	
Beryllium concentrate	Utah	Ariz. and S. Dak.
Boron minerals	Calif.	
Bromine	Ark. and Mich.	
Calcium-chloride	Mich. and Calif.	
Carbon dioxide (natural)	N. Mex., Colo., Calif., Utah.	
Cement	Calif., Tex., Pa., Mich.	Ala., Ariz., Ark., Colo., Fla., Ga., Hawaii, Idaho, Ill., Ind., Iowa, Kans., Ky., La., Maine, Md., Miss., Mo., Mont., Nebr., Nev., N. Mex., N.Y., N.C., Ohio, Okla., Oreg., S.C., S. Dak., Tenn., Utah, Va., Wash., W. Va., Wis., Wyo.
Clays	Ga., Ohio, Tex., N.C	All other States except Alaska, R.I., Vt.
Coal	Ky., W. Va., Pa., Ill	Ala., Alaska, Ariz., Ark., Colo., Ga., Ind., Iowa, Kans., Md., Mo., Mont., N. Mex., N. Dak., Ohio, Okla., Tenn., Tex., Utah, Va., Wash., Wyo.
Copper (mine)	Ariz., Utah, N. Mex., Mont	Calif., Colo., Idaho, Maine, Mich., Mo., Nev., Pa., Tenn., Wash.
Diatomite	Calif., Nev., Wash	Kans. and Oreg.
Emery	N.Y.	
Feldspar	N.C., Conn., Ga., Calif	Ariz., Colo., Maine, Okla., S. Dak., Wyo.
Fluorspar	Ill., Ky., Tex., Nev	Ariz., Mont., Utah.
Garnet, abrasive	Idaho and N.Y.	
Gold (mine)	S. Dak., Nev., Utah, Ariz	Alaska, Calif., Colo., Idaho, Mont., N. Mex., Oreg., Tenn., Wash.
Graphite	Tex.	
Gypsum	Mich., Calif., Tex., Iowa	Ariz., Ark., Colo., Idaho, Ind., Kans., La., Mont., Nev., N. Mex., N.Y., Ohio, Okla., S. Dak., Utah, Va., Wash., Wyo.
Helium	Kans., Okla., Tex	Ariz. and N. Mex.
Iodine	Mich.	
Iron ore	Minn., Mich., Calif., Wyo	Ariz., Colo., Ga., Mo., Mont., Nev., N.Y., Pa., S. Dak., Tex., Utah, Wis.
Kyanite	Va. and Ga.	
Lead (mine)	Mo., Idaho, Colo., Utah	Alaska, Ariz., Calif., Ill., Maine, Mont., Nev., N. Mex., N.Y., Okla., Va., Wash., Wis.
Lime	Ohio, Pa., Mo., Mich	Ala., Ariz., Ark., Calif., Colo., Conn., Fla., Hawaii, Idaho, Ill., Ind., Iowa, Kans., Ky., La., Md., Mass., Minn., Miss., Mont., Nebr., Nev., N.J., N. Mex., N.Y., N. Dak., Okla., Oreg., S. Dak., Tenn., Tex., Utah, Va., Wash., W. Va., Wis., Wyo.
Lithium minerals	N.C., Nev., Calif.	
Magnesite	Nev.	
Magnesium chloride	Tex.	
Magnesium compounds	Mich, Calif., N.J., Fla	Del., Miss., Tex., Utah.
Manganiferous ore	Minn., N. Mex., S.C.	
Manganiferous residuum	N.J.	
Marl, greensand	N.J.	
Mercury	Nev. and Calif.	
Mica, scrap	N.C., Ala., N. Mex., Ga	Ariz., Conn., Pa., S.C.
Molybdenum	Colo., Ariz., N. Mex., Utah	Calif. and Nev.
Natural gas	Tex., La., Okla., N. Mex	Ala., Alaska, Ariz., Ark., Calif., Colo., Fla., Ill., Ind., Kans., Ky., Md., Mich., Miss., Mo., Mont., Nebr., N.Y., N. Dak., Ohio, Pa., Tenn., Utah, Va., W. Va., Wyo.
Natural gas liquids	Tex., La., Okla., N. Mex	Ala., Alaska, Ark., Calif., Colo., Fla., Ill., Kans., Ky., Mich., Miss., Mont., Nebr., N. Dak., Pa., S. Dak., Utah, W. Va., Wyo.
Nickel	Oreg.	
Olivine	N.C. and Wash.	
Peat	Mich., Ind., Pa., Ill	Calif., Colo., Fla., Ga., Iowa, Maine, Md., Mass., Minn., Mont., N.J., N.Y., N. Dak., Ohio, S.C., Wash., Wis.
Perlite	N. Mex., Ariz., Calif., Idaho	Colo. and Nev.

Table 3.—Minerals produced in the United States and principal producing States in 1976 —Continued

Mineral	Principal producing States, in order of quantity	Other producing States
Petroleum, crude	Tex., La., Calif., Okla	Ala., Alaska, Ariz., Ark., Colo., Fla., Ill., Ind., Kans., Ky., Mich., Miss., Mo., Mont., Nebr., Nev., N. Mex., N.Y., N. Dak., Ohio, Pa., S. Dak., Tenn., Utah, Va., W. Va., Wyo.
Phosphate rock	Fla., Idaho, N.C., Tenn	Ark., Calif., Mo., Mont., Utah, Wyo.
Platinum-group metals	Alaska.	
Potassium salts	N. Mex., Utah, Calif.	
Pumice	Oreg., Ariz., Calif., N. Mex	Colo., Hawaii, Idaho, Mont., Nev., Okla., Utah.
Pyrites ore and concentrate	Tenn., Colo., Ariz.	
Rare-earth metal concentrate	Calif. and Fla.	
Salt	La., Tex., N.Y., Ohio	Ala., Ariz., Calif., Colo., Kans., Mich., Nev., N. Mex., N. Dak., Okla., Utah, W. Va.
Sand and gravel	Calif., Alaska, Tex., Mich	All other States.
Silver (mine)	Idaho, Ariz., Colo., Mont	Alaska, Calif., Ill., Maine, Mich., Mo., Nev., N. Mex., N.Y., S. Dak., Tenn., Utah, Va., Wash.
Sodium carbonate (natural)	Wyo. and Calif.	
Sodium sulfate (natural)	Calif., Tex., Utah.	
Staurolite	Fla.	
Stone	Pa., Ill., Tex., Mo	All other States except Del. and N. Dak.
Sulfur (Frasch)	Tex. and La.	
Talc, soapstone, pyrophyllite	Vt., Mont., N.Y., Tex	Ark., Calif., Ga., Nev., N.C., Oreg., Va., Wash.
Tin	Colo. and N. Mex.	
Titanium concentrate	Fla., N.J., N.Y.	
Tripoli	Ill., Okla., Ark., Pa.	
Tungsten concentrate	Calif., Colo., Nev	Ariz., Idaho, Mont., Oreg., Utah, Wash.
Uranium	N. Mex., Wyo., Utah, Colo	Tex. and Wash.
Vanadium	Ark., Colo., Idaho, Utah	N. Mex.
Vermiculite	Mont. and S.C.	
Wollastonite	N.Y.	
Zinc (mine)	Mo., Tenn., N.Y., Colo	Alaska, Ariz., Calif., Idaho, Ill., Ky., Maine, Mont., Nev., N.J., N. Mex., Okla., Pa., Utah, Va., Wash., Wis.
Zircon concentrate	Fla.	

Table 4.—Value of mineral production in the United States and principal minerals produced in 1976

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$1,029,536	20	1.49	Coal, petroleum, cement, stone.
Alaska	625,188	23	.90	Petroleum, sand and gravel, natural gas, stone.
Arizona	1,726,621	10	2.50	Copper, molybdenum, sand and gravel, cement.
Arkansas	535,448	25	.77	Petroleum, bromine, natural gas, cement.
California	3,483,373	4	5.04	Petroleum, natural gas, cement, sand and gravel.
Colorado	1,110,166	18	1.60	Petroleum, molybdenum, coal, natural gas.
Connecticut	34,318	47	.05	Stone, sand and gravel, feldspar, lime.
Delaware	[1]1,837	50	([2])	Sand and gravel, magnesium compounds, clays, gem stones.
Florida	1,652,232	11	2.39	Phosphate rock, petroleum, cement, stone.
Georgia	428,479	28	.62	Clays, stone, cement, sand and gravel.
Hawaii	42,252	44	.06	Stone, cement, sand and gravel, pumice.
Idaho	210,246	33	.30	Silver, phosphate rock, zinc, lead.
Illinois	1,581,165	12	2.29	Coal, petroleum, stone, sand and gravel.
Indiana	607,321	24	.88	Coal, cement, stone, petroleum.
Iowa	216,027	32	.31	Cement, stone, sand and gravel, coal.
Kansas	1,213,853	16	1.75	Petroleum, natural gas, natural gas liquids, stone.
Kentucky	3,114,589	5	4.50	Coal, petroleum, stone, natural gas.
Louisiana	8,652,107	2	12.51	Petroleum, natural gas, natural gas liquids, sulfur.
Maine	40,364	45	.06	Sand and gravel, cement, zinc, stone.
Maryland	184,918	36	.27	Coal, stone, cement, sand and gravel.
Massachusetts	69,850	43	.10	Stone, sand and gravel, lime, clays.
Michigan	1,543,516	13	2.23	Iron ore, petroleum, cement, natural gas.
Minnesota	1,218,030	15	1.76	Iron ore, sand and gravel, stone, lime.
Mississippi	449,862	26	.65	Petroleum, natural gas, cement, sand and gravel.
Missouri	785,160	21	1.13	Lead, cement, stone, iron ore.
Montana	636,289	22	.92	Petroleum, coal, copper, cement.
Nebraska	123,365	39	.18	Petroleum, cement, sand and gravel, stone.
Nevada	233,683	31	.34	Copper, gold, sand and gravel, barite.
New Hampshire	17,579	48	.03	Sand and gravel, stone, clays, gem stones.
New Jersey	119,886	40	.17	Sand and gravel, stone, zinc, titanium concentrate.
New Mexico	2,510,127	8	3.63	Petroleum, natural gas, copper, natural gas liquids.
New York	427,964	29	.62	Cement, stone, salt, sand and gravel.
North Carolina	203,339	34	.29	Stone, phosphate rock, sand and gravel, lithium minerals.
North Dakota	244,105	30	.35	Petroleum, coal, natural gas, natural gas liquids.
Ohio	1,435,896	14	2.08	Coal, petroleum, lime, stone.
Oklahoma	2,789,974	7	4.03	Petroleum, natural gas, natural gas liquids, coal.
Oregon	112,566	41	.16	Stone, sand and gravel, cement, nickel.
Pennsylvania	3,041,186	6	4.40	Coal, cement, stone, lime.
Rhode Island	6,400	49	.01	Sand and gravel, stone, gem stones.
South Carolina	125,455	38	.18	Cement, stone, clays, sand and gravel.
South Dakota	101,530	42	.15	Gold, cement, stone, sand and gravel.
Tennessee	439,714	27	.64	Coal, stone, zinc, cement.
Texas	18,143,204	1	26.23	Petroleum, natural gas, natural gas liquids, cement.
Utah	1,043,981	19	1.51	Petroleum, copper, coal, uranium.
Vermont	35,097	46	.05	Stone, asbestos, sand and gravel, talc.
Virginia	1,160,645	17	1.68	Coal, stone, cement, lime.
Washington	187,222	35	.27	Cement, coal, sand and gravel, stone.
West Virginia	3,498,001	3	5.06	Coal, natural gas, petroleum, natural gas liquids.
Wisconsin	132,453	37	.19	Sand and gravel, stone, iron ore, cement.
Wyoming	1,851,599	9	2.68	Petroleum, sodium compounds, coal, natural gas.
Total	69,178,000	--	100.00	

[1]Incomplete total.
[2]Less than 1/2 unit.

Table 5.—Value of mineral production per capita and per square mile in 1976, by State

State	Area (square miles)	1976 population (thousands)	Value of mineral production: Total (thousands)	Per square mile: Dollars	Per square mile: Rank	Per capita: Dollars	Per capita: Rank
Alabama	51,609	3,665	$1,029,536	19,949	14	281	17
Alaska	586,412	382	625,188	1,066	49	1,637	5
Arizona	113,909	2,270	1,726,621	15,158	19	761	11
Arkansas	53,104	2,109	535,448	10,083	26	254	19
California	158,693	21,520	3,483,373	21,950	12	162	26
Colorado	104,247	2,583	1,110,166	10,649	24	430	13
Connecticut	5,009	3,117	34,318	6,851	31	11	48
Delaware	2,057	582	[1]1,837	893	50	3	50
Florida	58,560	8,421	1,652,232	28,214	9	196	22
Georgia	58,876	4,970	428,479	7,278	30	86	32
Hawaii	6,450	887	42,252	6,530	32	48	38
Idaho	83,557	831	210,246	2,516	41	253	20
Illinois	56,400	11,229	1,581,165	28,035	10	141	28
Indiana	36,291	5,302	607,321	16,735	17	115	30
Iowa	56,290	2,870	216,027	5,838	33	75	34
Kansas	82,264	2,310	1,213,853	14,755	20	525	12
Kentucky	40,395	3,428	3,114,589	77,103	3	909	8
Louisiana	48,523	3,841	8,652,107	178,309	1	2,253	2
Maine	33,215	1,070	40,364	1,215	47	38	41
Maryland	10,577	4,144	184,918	17,483	16	45	39
Massachusetts	8,257	5,809	69,850	8,459	29	12	47
Michigan	58,216	9,104	1,543,516	26,514	11	170	24
Minnesota	84,068	3,965	1,218,030	14,489	21	307	16
Mississippi	47,716	2,354	449,862	9,428	27	191	23
Missouri	69,686	4,778	785,160	11,267	23	164	25
Montana	147,138	753	636,289	4,324	35	845	10
Nebraska	77,227	1,553	123,365	1,597	45	79	33
Nevada	110,540	610	233,683	2,114	43	383	14
New Hampshire	9,304	822	17,579	1,889	44	21	45
New Jersey	7,836	7,336	119,886	15,299	18	16	46
New Mexico	121,666	1,168	2,510,127	20,631	13	2,149	3
New York	49,576	18,084	427,964	8,632	28	24	44
North Carolina	52,586	5,469	203,339	3,867	37	37	42
North Dakota	70,665	643	244,105	3,454	39	380	15
Ohio	41,222	10,690	1,435,896	34,833	7	134	29
Oklahoma	69,919	2,766	2,789,974	39,903	6	1,008	7
Oregon	96,981	2,329	112,566	1,161	48	48	37
Pennsylvania	45,333	11,862	3,041,186	67,085	5	256	18
Rhode Island	1,214	927	6,400	5,272	34	7	49
South Carolina	31,055	2,848	125,455	4,040	36	44	40
South Dakota	77,047	686	101,530	1,318	46	148	27
Tennessee	42,244	4,214	439,714	10,409	25	104	31
Texas	267,338	12,487	18,143,204	67,866	4	1,453	6
Utah	84,916	1,228	1,043,981	12,294	22	850	9
Vermont	9,609	476	35,097	3,653	38	74	35
Virginia	40,817	5,032	1,160,645	28,435	8	231	21
Washington	68,192	3,612	187,222	2,746	40	52	36
West Virginia	24,181	1,821	3,498,001	144,659	2	1,921	4
Wisconsin	56,154	4,609	132,453	2,359	42	29	43
Wyoming	97,914	390	1,851,599	18,910	15	4,748	1
Total[2]	3,615,055	213,956	69,178,000	19,136	XX	323	XX

XX Not applicable.
[1]Incomplete total.
[2]Excludes Washington, D.C., with an area of 67 square miles and a population of 702,000 (which had no mineral production).

Table 6.—Mineral production[1] in the United States, by State

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
ALABAMA								
Cement:								
Masonry ---------- thousand short tons	[2]425	[2]$13,074	314	$11,322	262	$10,253	314	$13,671
Portland ---------- do	2,396	55,820	2,190	61,990	1,968	62,599	2,134	70,365
Clays[3] ---------- do	2,934	8,788	2,995	13,298	2,231	9,077	2,239	10,325
Coal (bituminous) ---------- do	19,230	211,695	19,824	432,036	22,644	600,767	21,537	611,069
Iron ore (usable) ---------- thousand long tons, gross weight	271	1,408	W	W	W	W	--	--
Lime ---------- thousand short tons	881	14,050	1,054	22,346	985	29,404	1,009	32,753
Natural gas ---------- million cubic feet	11,271	4,307	27,865	20,704	37,814	32,898	41,427	40,806
Petroleum (crude) ---------- thousand 42-gallon barrels	11,677	41,772	13,323	113,808	13,477	136,541	14,706	155,437
Sand and gravel ---------- thousand short tons	9,805	13,870	12,454	19,120	9,232	17,376	12,023	20,933
Stone ---------- do	[4]20,043	[4]40,117	[4]23,773	[4]60,231	22,252	61,515	23,832	65,429
Value of items that cannot be disclosed: Asphalt (native), bauxite, cement (slag 1973), clay (bentonite), mica (scrap), natural gas liquids, salt, stone (dimension 1973-74), talc (1973-75), and values indicated by W	XX	8,155	XX	9,891	XX	8,543	XX	8,748
Total	XX	413,056	XX	764,746	XX	968,973	XX	1,029,536
ALASKA								
Barite ---------- thousand short tons	W	W	20	401	2	30	--	--
Coal (bituminous) ---------- do	694	W	700	W	766	W	706	W
Gem stones ----------	NA	57	NA	57	NA	57	NA	60
Gold (recoverable content of ores, etc.) ---------- troy ounces	7,107	695	9,146	1,461	14,980	2,419	22,887	2,868
Lead (recoverable content of ores, etc.) ---------- short tons	6	2	--	--	--	--	14	6
Natural gas ---------- million cubic feet	131,007	19,483	128,935	21,919	160,270	48,402	166,072	64,602
Petroleum (crude) ---------- thousand 42-gallon barrels	72,323	261,877	70,603	347,408	69,834	364,630	63,398	318,789
Sand and gravel ---------- thousand short tons	14,999	19,913	43,644	22,954	48,145	25,780	74,208	204,738
Silver (recoverable content of ores, etc.) ---------- thousand troy ounces	1	2	1	3	W	W	3	14
Stone ---------- thousand short tons	5,967	12,741	5,484	12,947	8,877	26,649	6,727	20,092
Tin ---------- metric tons	5	12	W	W	11	60	--	--
Value of items that cannot be disclosed: Copper (1974), mercury (1973-74), natural gas liquids, platinum-group metals, uranium (1973), and values indicated by W	XX	14,156	XX	11,453	XX	12,718	XX	14,019
Total	XX	328,938	XX	418,603	XX	480,745	XX	625,188

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
ARIZONA								
Clays ____ thousand short tons	[3]117	[3]$459	199	$622	129	$483	[3]28	[3]$361
Coal (bituminous) ____ do	3,247	W	6,448	W	6,986	W	10,420	W
Copper ____ short tons	927,271	1,103,453	858,783	1,327,678	813,211	1,044,162	1,024,421	1,425,994
Gem stones	NA	170	NA	1,500	NA	5,000	NA	4,000
Gold (recoverable content of ores, etc.) ____ troy ounces	102,848	10,060	90,586	14,470	85,790	13,854	102,062	12,790
Gypsum ____ thousand short tons	158	669	141	473	117	419	139	529
Lead (recoverable content of ores, etc.) ____ short tons	763	248	1,059	476	420	181	338	156
Lime ____ thousand short tons	365	7,019	422	9,071	512	12,444	546	16,115
Mica (scrap) ____ do	W	W	2	82	2	65	W	W
Molybdenum (content of concentrate) ____ thousand pounds	37,657	59,372	28,346	57,067	25,030	61,411	31,073	89,148
Natural gas ____ million cubic feet	125	23	224	45	208	58	262	74
Petroleum (crude) ____ thousand 42-gallon barrels	804	3,103	740	3,885	635	3,332	519	2,724
Pumice ____ thousand short tons	853	715	846	865	856	1,294	802	1,240
Sand and gravel ____ do	27,440	38,503	23,417	41,906	17,222	36,490	[5]18,131	[5]40,184
Silver (recoverable content of ores, etc.) ____ thousand troy ounces	7,199	18,416	6,356	29,935	6,286	27,783	7,615	33,126
Stone ____ thousand short tons	4,265	9,469	4,932	11,479	3,404	11,030	4,147	13,921
Zinc (recoverable content of ores, etc.) ____ short tons	8,427	3,482	9,699	6,964	8,655	6,751	9,501	7,030
Value of items that cannot be disclosed: Asbestos, beryl concentrate (1976), cement, clays (fire, 1973; ball and common, 1976), feldspar, fluorspar, (1973, 1976), helium (high purity), iron ore, perlite, pyrite, salt (1975-76), sand and gravel (industrial, 1976), tungsten, and values indicated by W	XX	49,827	XX	55,716	XX	63,666	XX	79,229
Total	XX	1,304,988	XX	1,562,234	XX	1,288,423	XX	1,726,621
ARKANSAS								
Bauxite ____ thousand long tons, dried equivalent	1,686	23,884	1,731	23,597	1,543	22,956	1,667	24,481
Clays ____ thousand short tons	[3]1,446	[3]1,412	984	1,597	995	2,232	1,047	3,396
Coal (bituminous) ____ do	434	5,806	455	9,673	488	16,000	534	19,310
Gem stones	NA	50	NA	60	NA	70	NA	85
Iron ore ____ thousand long tons, gross weight	W	W	4	W	([6])	14	--	--
Lime ____ thousand short tons	177	2,742	187	3,189	170	3,848	182	4,900
Natural gas ____ million cubic feet	157,529	28,985	123,975	32,234	116,237	40,334	109,533	58,052
Natural gas liquids:								
Natural gasoline and cycle products ____ thousand 42-gallon barrels	204	861	199	1,344	196	1,360	203	1,422
LP gases ____ do	449	1,688	418	2,491	407	2,377	408	2,440
Petroleum (crude) ____ do	18,016	70,618	16,527	122,817	16,133	143,336	18,097	174,636
Sand and gravel ____ thousand short tons	12,465	20,625	14,878	29,922	12,415	25,794	[5]14,736	[5]25,848

Stone ......do....	16,223	26,209	20,381	38,905	17,419	38,796	[4]17,701	[4]39,713
Value of items that cannot be dislclosed: Abrasive stones, barite, bromine, cement, clays (kaolin, 1973), gypsum, phosphate rock (1975-76), sand and gravel (industrial, 1976), stone (dimension, 1976), soapstone, tripoli, vanadium, and values indicated by W	XX	90,825	XX	140,589	XX	139,324	XX	181,165
Total	XX	273,705	XX	406,418	XX	436,441	XX	535,448
CALIFORNIA								
Asbestos ......short tons..	105,663	10,886	58,331	5,697	W	W	78,390	15,706
Barite......thousand short tons..	11	152	4	W	1	W	--	--
Boron minerals ......do....	1,225	113,648	1,185	128,306	1,172	158,772	1,246	184,852
Cement......do....	9,395	201,892	8,264	210,520	7,327	232,584	7,897	293,693
Clays ......do....	2,723	6,853	2,497	7,626	[3]2,387	[3]7,373	2,295	13,570
Copper (recoverable content of ores, etc.)......short tons..	369	440	194	300	344	441	375	522
Diatomite ......do....	W	W	W	W	354	31,186	386	37,372
Gem stones	NA	220	NA	220	NA	220	NA	231
Gold (recoverable content of ores, etc.) ......troy ounces..	3,647	357	5,049	807	9,606	1,551	10,392	1,302
Gypsum ......thousand short tons..	1,778	5,834	1,716	6,642	1,446	6,332	1,647	7,897
Lead (recoverable content of ores, etc.) ......short tons..	44	14	35	16	66	28	54	25
Lime ......thousand short tons..	632	13,602	600	14,877	595	18,626	638	23,824
Magnesium compounds from seawater and bitterns (partly estimated) ......short tons, MgO content..	184,105	19,233	163,847	18,356	W	W	W	W
Mercury ......76-pound flasks..	1,219	349	1,311	370	W	W	296	36
Natural gas ......million cubic feet..	449,369	167,615	365,354	160,756	318,308	222,816	354,334	333,074
Natural gas liquids:								
Natural gasoline and cycle products .. thousand 42-gallon barrels..	6,865	23,475	5,709	26,104	4,847	29,543	4,626	31,655
LP gases ......do....	5,329	19,824	5,095	29,296	4,481	20,568	4,151	25,487
Peat......thousand short tons..	21	373	14	322	W	W	W	W
Petroleum (crude) ......thousand 42-gallon barrels..	336,075	1,045,193	323,003	1,710,350	322,199	1,943,048	326,021	2,005,577
Pumice......thousand short tons..	768	3,237	909	3,219	348	2,762	705	3,245
Rare-earth metal concentrates......short tons..	W	W	34,284	15,798	W	W	W	W
Salt......thousand short tons..	1,507	15,533	W	W	W	W	W	W
Sand and gravel......do....	117,470	176,286	105,191	176,213	88,445	168,248	96,592	202,272
Silver (recoverable content of ores, etc.) ......thousand troy ounces..	56	143	42	197	80	353	57	249
Stone......thousand short tons..	43,838	77,175	45,709	91,891	33,152	72,740	32,377	75,352
Talc, soapstone, pyrophyllite......short tons..	179,191	1,501	163,841	1,676	152,978	1,598	56,871	1,513
Zinc (recoverable content of ores, etc.) ......do....	20	8	8	6	206	161	170	126
Value of items that cannot be disclosed: Bromine (1973-75), calcium-magnesium chloride, carbon dioxide, cement (masonry, 1973), clays (ball and kaolin, 1975), feldspar, iron ore, lithium minerals, molybdenum, perlite, phosphate rock (1976), potassium salts, sodium carbonate and sulfate, tungsten concentrate, and values indicated by W	XX	137,843	XX	187,684	XX	233,987	XX	226,293
Total	XX	2,041,686	XX	2,797,249	XX	3,152,937	XX	3,483,373

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
COLORADO								
Carbon dioxide ---- thousand cubic feet	W	W	123,106	W	229,382	W	317,720	W
Clays ---- thousand short tons	794	$1,710	663	$1,588	480	$1,101	[3]479	[3]$1,976
Coal (bituminous) ---- do	6,233	46,190	6,896	64,677	8,219	135,872	9,437	144,364
Copper (recoverable content of ores, etc.) ---- short tons	3,123	3,716	3,012	4,657	3,560	4,571	2,431	3,384
Gem stones	NA	131	NA	135	NA	145	NA	142
Gold (recoverable content of ores, etc.) ---- troy ounces	63,422	6,203	52,083	8,320	55,483	8,960	50,764	6,362
Gypsum ---- thousand short tons	151	568	191	800	185	782	215	984
Lead (recoverable content of ore, etc.) ---- short tons	28,112	9,159	24,609	11,074	27,088	11,648	26,749	12,358
Lime ---- thousand short tons	178	3,371	198	3,815	198	4,577	185	4,406
Natural gas ---- million cubic feet	137,725	24,304	144,629	28,926	171,629	44,624	183,972	88,307
Natural gas liquids:								
Natural gasoline and cycle products ---- thousand 42-gallon barrels	1,424	4,295	1,574	9,319	1,742	9,378	1,904	13,403
LP gases ---- do	1,978	6,488	2,580	14,190	4,821	22,803	6,505	38,249
Peat ---- thousand short tons	28	163	30	201	37	280	33	238
Petroleum (crude) ---- thousand 42-gallon barrels	36,590	155,507	37,508	283,904	38,089	365,654	38,992	376,273
Sand and gravel ---- thousand short tons	33,767	45,493	23,793	39,674	20,019	34,850	[5]20,160	[5]32,900
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	3,598	9,204	2,784	13,113	3,366	14,878	4,083	17,762
Stone ---- thousand short tons	6,357	14,003	6,572	15,109	5,315	10,940	5,294	12,555
Uranium (recoverable content of U_3O_8) ---- thousand pounds	1,888	12,274	W	W	W	W	W	W
Zinc (recoverable content of ores, etc.) ---- short tons	58,339	24,106	49,489	35,533	48,460	37,799	50,621	37,460
Value of items that cannot be disclosed: Cement, clays (bentonite, 1976), feldspar, fluorspar (1973-74), iron ore, molybdenum, perlite, pumice, pyrites, salt, sand and gravel (industrial, 1976), tin, tungsten, vanadium, and values indicated by W	XX	164,806	XX	215,264	XX	[r]249,211	XX	319,043
Total	XX	531,691	XX	750,299	XX	[r]958,073	XX	1,110,166
CONNECTICUT								
Clays ---- thousand short tons	162	320	156	363	116	307	130	427
Feldspar ---- short tons	77,206	W	W	W	W	W	W	W
Gem stones	NA	16	NA	15	NA	W	NA	W
Lime ---- thousand short tons	W	W	33	1,148	23	1,013	24	1,103
Mica, scrap ---- do	3	W	2	W	W	W	W	W
Sand and gravel ---- do	7,806	12,788	6,345	11,272	4,900	10,040	6,414	12,978
Stone ---- do	9,682	21,305	8,457	21,134	7,322	20,117	6,016	17,598

Value of items that cannot be disclosed: Mica (sheet, 1974), and values indicated by W	XX	2,375	XX	1,430	XX	1,533	XX	2,212
Total	XX	36,804	XX	35,362	XX	33,010	XX	34,318
DELAWARE								
Clays ... thousand short tons	15	9	14	8	9	6	11	8
Gem stones	NA	W	NA	2	NA	W	NA	W
Sand and gravel ... thousand short tons	3,408	3,678	2,396	3,783	976	1,900	1,117	1,829
Value of items that cannot be disclosed: Other nonmetals and values indicated by W	XX	202	XX	W	XX	W	XX	W
Total	XX	3,889	XX	[7]3,793	XX	[7]1,906	XX	[7]1,837
FLORIDA								
Cement:								
Masonry ... thousand short tons	256	8,706	235	4,737	W	W	W	W
Portland ... do	2,725	72,666	2,562	75,133	1,721	62,525	1,949	67,832
Clays ... do	1,139	13,718	808	14,261	712	17,068	680	20,672
Lime ... do	187	4,026	185	5,315	199	7,708	179	7,798
Natural gas ... million cubic feet	33,857	11,613	38,137	20,441	44,383	43,185	43,165	42,388
Peat ... thousand short tons	44	384	67	616	82	1,037	79	1,287
Petroleum ... thousand 42-gallon barrels	32,695	150,070	36,351	351,331	41,877	490,258	44,460	499,573
Sand and gravel ... thousand short tons	20,167	21,415	24,372	33,400	13,237	20,199	13,204	19,164
Stone[4] ... do	61,375	103,595	54,560	100,378	39,071	73,372	38,606	74,412
Titanium concentrates (rutile) ... short tons	9,045	1,212	6,446	996	W	W	W	W
Value of items that cannot be disclosed: Clay (kaolin, 1974), kyanite (1973), magnesium compounds, natural gas liquids, phosphate rock, rare-earth metal concentrate, staurolite, stone (dimension), titanium concentrate (ilmenite), zircon concentrate, and values indicated by W	XX	213,695	XX	437,287	XX	1,060,153	XX	919,106
Total	XX	601,100	XX	1,043,895	XX	1,775,500	XX	1,652,232
GEORGIA								
Cement:								
Masonry ... thousand short tons	67	2,126	40	1,304	W	W	W	W
Portland ... do	1,201	28,124	1,150	31,535	828	25,822	930	30,085
Clays ... do	[3]7,721	[3]160,419	[3]7,692	[3]203,936	6,156	195,300	7,471	273,145
Coal (bituminous) ... do	--	--	--	--	W	W	186	6,152
Feldspar ... short tons	51,523	W	W	W	W	W	W	W
Peat ... thousand short tons	([6])	4	1	6	([6])	5	W	W
Sand and gravel ... do	4,976	6,781	4,989	9,639	5,105	8,818	4,835	8,387
Stone ... do	40,841	97,506	40,321	105,582	30,084	91,157	31,855	98,806
Talc ... short tons	38,000	114	33,850	102	27,400	82	W	W

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
GEORGIA—Continued								
Value of items that cannot be disclosed: Barite, bauxite, fire clay (1973-74), iron ore, kyanite, mica (scrap), rare-earth metal concentrate (1973-74), titanium concentrate (1973-74), zircon concentrate (1973-74), and values indicated by W	XX	$10,405	XX	$10,996	XX	$12,203	XX	$11,904
Total	XX	305,479	XX	363,100	XX	333,387	XX	428,479
HAWAII								
Cement:								
Masonry ... thousand short tons	16	537	14	706	13	762	11	663
Portland ... do	453	13,213	487	16,405	456	19,942	328	17,747
Gem stones	NA	W	NA	W	NA	W	NA	W
Lime ... thousand short tons	6	238	6	221	6	250	W	W
Pumice, pumicite, volcanic ash ... do	354	611	385	792	318	912	330	636
Sand and gravel ... do	753	2,012	990	2,379	671	2,460	573	1,634
Stone ... do	7,180	18,466	[4]7,638	[4]21,370	7,569	25,319	[4]6,092	[4]21,193
Value of items that cannot be disclosed: Clays, salt (1973), stone (dimension, 1974, 1976), and values indicated by W	XX	70	XX	169	XX	65	XX	379
Total	XX	35,147	XX	42,042	XX	49,710	XX	42,252
IDAHO								
Antimony ore and concentrate ... short tons, antimony content	322	406	445	W	W	W	133	W
Clays ... thousand short tons	42	227	[3]9	[3]10	30	284	W	W
Copper (recoverable content of ores, etc.) ... short tons	3,625	4,314	2,841	4,393	3,192	4,099	3,362	4,680
Gem stones	NA	110	NA	120	NA	120	NA	126
Gold (recoverable content of ores, etc.) ... troy ounces	2,696	264	2,898	463	2,529	408	2,755	345
Lead (recoverable content of ores, etc.) ... short tons	61,744	20,116	51,717	23,273	50,395	21,670	53,636	24,780
Pumice ... thousand short tons	80	110	108	182	111	187	W	W
Sand and gravel ... do	8,393	10,246	7,665	10,484	6,881	12,768	[5]6,549	[5]11,504
Silver (recoverable content of ores, etc.) ... thousand troy ounces	13,620	34,840	12,436	58,572	13,868	61,297	11,561	50,292
Stone ... thousand short tons	2,972	8,096	3,528	9,868	3,316	8,952	[4]3,462	[4]9,122
Zinc (recoverable content of ores, etc.) ... short tons	46,107	19,052	39,469	28,339	40,926	31,922	46,586	34,473

Value of items that cannot be disclosed: Barite (1974-76), cement, clays (fire clay and kaolin, 1974), garnet (abrasive), gypsum, iron ore (1973-75), lime, perlite, phosphate rock, sand and gravel (industrial, 1976), stone (dimension, 1976), tungsten concentrate, vanadium, and values indicated by W	XX	38,300	XX	72,854	XX	92,081	XX	74,924
Total	XX	136,081	XX	208,558	XX	233,788	XX	210,246
ILLINOIS								
Cement:								
Masonry ... thousand short tons	88	2,901	69	3,228	W	W	W	W
Portland ... do	1,572	36,064	1,460	41,023	1,374	42,756	1,632	53,524
Clays[3] ... do	1,758	3,613	1,587	3,744	1,366	3,249	1,309	3,272
Coal (bituminous) ... do	61,572	413,309	58,215	582,010	59,537	871,377	58,239	925,968
Fluorspar ... short tons	160,305	11,871	151,898	12,247	99,898	8,957	142,666	14,563
Gem stones	NA	2	NA	2	NA	2	NA	2
Lead (recoverable content of ores, etc.) ... short tons	541	176	493	222	W	W	W	W
Natural gas ... million cubic feet	1,688	573	1,436	574	1,440	1,008	1,556	1,533
Peat ... thousand short tons	72	1,037	96	1,412	96	1,511	87	763
Petroleum (crude) ... thousand 42-gallon barrels	30,669	132,490	27,553	244,395	26,067	273,182	26,272	267,449
Sand and gravel ... thousand short tons	43,649	62,029	42,705	68,566	39,000	83,515	38,784	87,152
Stone ... do	66,653	114,068	63,231	121,763	60,640	130,104	61,862	141,543
Zinc (recoverable content of ores, etc.) ... short tons	5,250	2,169	4,104	2,947	W	W	W	W
Value of items that cannot be disclosed: Barite (1974-76), clay (fuller's earth), copper (1974), lime, natural gas liquids, silver, tripoli, and values indicated by W	XX	45,306	XX	65,517	XX	74,937	XX	85,396
Total	XX	825,608	XX	1,147,650	XX	1,490,598	XX	1,581,165
INDIANA								
Cement:								
Masonry ... thousand short tons	W	W	W	W	343	12,263	396	14,270
Portland ... do	W	W	W	W	2,185	63,077	2,490	73,432
Clays ... do	1,436	2,568	1,092	1,947	1,094	1,961	1,265	2,308
Coal (bituminous) ... do	25,253	153,136	23,726	198,410	25,124	280,130	25,369	312,990
Natural gas ... million cubic feet	276	38	176	25	346	135	192	100
Peat ... thousand short tons	51	475	71	946	76	1,918	144	1,716
Petroleum (crude) ... thousand 42-gallon barrels	5,312	20,823	4,919	42,402	4,632	48,821	4,630	50,421
Sand and gravel ... thousand short tons	27,731	35,015	26,077	35,656	21,641	35,234	25,884	45,521
Stone ... do	[4]32,288	[4]57,652	[4]31,031	[4]64,106	28,947	68,850	28,450	72,205
Value of items that cannot be disclosed: Abrasive stone, gypsum, lime, sandstone (1973-74), and values indicated by W	XX	81,698	XX	97,198	XX	[r]29,211	XX	34,358
Total	XX	351,405	XX	440,690	XX	541,600	XX	607,321

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
IOWA								
Cement:								
Masonry ---- thousand short tons	68	$2,351	65	$2,660	62	$2,933	76	$4,143
Portland ---- do	2,688	59,574	2,424	64,156	2,258	73,786	2,438	86,107
Clays ---- do	967	2,028	960	1,869	959	1,916	1,017	2,245
Coal (bituminous) ---- do	601	3,279	590	4,591	622	6,891	616	8,351
Gem stones	NA	W	NA	W	NA	W	NA	1
Gypsum ---- thousand short tons	1,470	6,324	1,397	7,142	1,208	6,546	1,486	8,288
Sand and gravel ---- do	19,950	25,541	17,091	26,104	15,410	26,844	[5]15,206	[5]26,277
Stone ---- do	31,541	56,918	32,342	66,119	30,336	73,732	[4]30,272	[4]75,921
Value of items that cannot be disclosed: Lime, peat, sand and gravel (industrial, 1976), stone (dimension, 1976), and values indicated by W	XX	2,785	XX	4,079	XX	3,092	XX	4,694
Total	XX	[r]158,800	XX	176,720	XX	195,740	XX	216,027
KANSAS								
Cement:								
Masonry ---- thousand short tons	73	2,068	64	2,203	57	2,311	72	3,281
Portland ---- do	2,026	42,172	1,940	46,940	1,832	55,033	2,005	66,478
Clays ---- do	1,169	1,490	1,311	1,785	1,178	1,604	[3]1,064	[3]1,869
Coal (bituminous) ---- do	1,086	7,979	718	5,463	479	9,481	590	11,473
Helium:								
Crude ---- million cubic feet	1,539	18,468	W	W	W	W	W	W
High-purity ---- do	416	8,736	499	11,477	497	11,928	503	11,066
Lime ---- thousand short tons	10	199	28	535	W	W	W	W
Natural gas ---- million cubic feet	893,118	138,521	886,782	147,206	843,625	145,103	829,170	348,251
Natural gas liquids:								
Natural gasoline ---- thousand 42-gallon barrels	5,993	17,685	6,630	24,810	6,295	25,062	6,434	31,017
LP gases ---- do	24,463	53,819	24,402	78,818	23,563	71,632	23,767	83,422
Petroleum (crude) ---- do	66,227	281,465	61,691	490,984	59,106	561,508	58,714	557,783
Salt[8] ---- thousand short tons	1,397	23,460	1,367	27,007	1,446	31,214	1,310	35,291
Sand and gravel ---- do	13,261	12,663	11,687	13,388	10,866	13,467	[5]12,291	[5]14,940
Stone ---- do	[4]18,334	[4]33,601	[4]17,869	34,869	15,907	35,850	[4]16,348	[4]38,228

Value of items that cannot be disclosed: Clays (bentonite, 1976), diatomite (1974-76), gypsum, pumice (1973-75), salt (brine), sand and gravel (industrial, 1976), stone (dimension, 1973, 1976), and values indicated by W	XX	3,973	XX	3,913	XX	6,418	XX	10,754
Total	XX	646,299	XX	889,398	XX	970,611	XX	1,213,853
KENTUCKY								
Clays[3] ... thousand short tons	1,083	1,961	848	1,477	778	1,483	754	2,395
Coal (bituminous) ... do	127,645	986,654	137,197	2,340,961	143,643	2,499,295	143,972	2,848,690
Natural gas ... million cubic feet	62,396	21,839	71,876	35,938	60,511	32,676	66,137	36,375
Petroleum (crude) ... thousand 42-gallon barrels	8,687	34,515	7,837	68,340	7,556	84,520	7,483	85,454
Sand and gravel ... thousand short tons	10,331	14,627	8,710	12,887	8,924	14,466	9,154	15,271
Stone ... do	[4]38,205	[4]70,912	35,452	66,632	31,734	67,906	33,378	77,060
Zinc (recoverable content of ores, etc.) ... short tons	273	113	--	--	41	32	59	44
Value of items that cannot be disclosed: Cement, clay (ball), fluorspar, lead (1975), lime, natural gas liquids, and stone (quartzite, 1973)	XX	34,141	XX	36,975	XX	38,481	XX	49,300
Total	XX	1,164,762	XX	2,563,210	XX	2,738,859	XX	3,114,589
LOUISIANA								
Clays ... thousand short tons	979	1,329	770	1,425	531	1,132	513	1,158
Lime ... do	897	16,801	796	17,665	485	12,484	W	W
Natural gas ... million cubic feet	8,242,423	1,846,303	7,753,631	2,380,365	7,090,645	2,999,179	7,006,596	3,223,034
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	47,906	167,037	35,860	234,954	31,808	178,930	27,078	151,683
LP gases ... do	102,701	253,671	108,439	423,996	103,714	392,039	91,701	375,057
Petroleum (crude) ... do	831,524	3,327,702	737,324	4,811,772	650,840	4,611,879	606,501	4,556,761
Salt ... thousand short tons	13,152	66,211	13,543	76,960	12,166	77,116	13,491	91,952
Sand and gravel ... do	13,748	21,165	12,341	27,781	14,587	35,990	22,528	51,293
Stone[4] ... do	10,802	21,309	10,940	24,046	10,489	38,260	9,685	28,127
Sulfur (Frasch process) ... thousand long tons	3,329	W	3,426	W	2,672	W	2,445	W
Value of items that cannot be disclosed: Cement, gypsum, stone (miscellaneous, 1973-74), and values indicated by W	XX	98,082	XX	147,614	XX	166,266	XX	173,042
Total	XX	5,819,610	XX	8,146,578	XX	8,513,275	XX	8,652,107
MAINE								
Clays ... thousand short tons	41	74	146	183	125	202	134	216
Copper ... short tons	1,107	1,317	1,522	2,353	2,024	2,599	1,766	2,459
Gem stones	NA	W	NA	W	NA	W	NA	1,105
Lead (recoverable content of ores, etc.) ... short tons	204	66	279	126	364	157	216	100

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
MAINE—Continued								
Peat ---- thousand short tons	5	$177	4	$194	4	$207	5	$173
Sand and gravel ---- do	13,583	10,304	8,755	10,673	9,875	11,403	[5]10,312	[5]13,950
Stone ---- do	1,212	3,329	1,491	4,255	[4]1,253	[4]3,741	1,443	4,609
Zinc (recoverable content of ores, etc.) ---- short tons	19,640	8,115	10,425	7,485	8,318	6,488	7,810	5,779
Value of items that cannot be disclosed: Cement, feldspar (1976), sand and gravel (industrial, 1976), silver, stone (dimension, 1975), and values indicated by W	XX	10,111	XX	11,079	XX	11,944	XX	11,973
Total	XX	33,493	XX	36,348	XX	36,741	XX	40,364
MARYLAND								
Clays[3] ---- thousand short tons	897	1,973	884	2,066	580	1,450	702	1,817
Coal (bituminous) ---- do	1,789	13,644	2,337	48,630	2,606	50,502	2,830	61,974
Gem stones	NA	8	NA	8	NA	W	NA	W
Lime ---- thousand short tons	W	W	23	527	15	434	16	494
Natural gas ---- million cubic feet	298	69	133	32	93	25	75	24
Peat ---- thousand short tons	2	29	3	45	2	39	2	W
Sand and gravel ---- do	12,845	29,625	11,690	29,386	11,786	29,477	12,942	31,914
Stone ---- do	18,585	46,732	18,072	47,630	14,796	43,110	15,709	47,669
Value of items that cannot be disclosed: Cement, clay (ball), talc and soapstone (1973-74), and items indicated by W	XX	39,827	XX	44,556	XX	39,882	XX	41,026
Total	XX	131,907	XX	172,880	XX	164,919	XX	184,918
MASSACHUSETTS								
Clays ---- thousand short tons	217	404	218	379	124	228	126	238
Gem stones	NA	5	NA	5	NA	W	NA	W
Lime ---- thousand short tons	W	W	170	4,972	152	5,215	178	6,354
Peat ---- do	2	78	3	85	W	W	W	W
Sand and gravel ---- do	18,743	26,910	17,334	26,565	13,281	24,556	16,084	29,666
Stone ---- do	8,580	28,738	8,103	30,103	7,170	28,681	7,937	33,502
Value of items that cannot be disclosed: Nonmetals and values indicated by W	XX	3,547	XX	--	XX	166	XX	90
Total	XX	59,682	XX	62,109	XX	58,846	XX	69,850

MICHIGAN									
Cement:									
Masonry	thousand short tons	247	6,185	217	6,309	183	6,429	218	8,370
Portland	do	6,242	123,442	5,903	140,513	4,573	131,324	4,931	145,381
Clays	do	2,151	3,304	2,161	4,074	1,818	3,580	1,934	4,741
Copper (recoverable content of ores, etc.)	short tons	72,221	85,943	67,012	103,601	73,690	94,618	43,707	60,840
Gem stones		NA	8	NA	8	NA	8	NA	10
Gypsum	thousand short tons	1,882	8,538	1,482	7,258	1,224	5,936	1,837	9,842
Iron ore (usable)	thousand long tons, gross weight	12,389	180,194	11,602	213,598	14,089	339,113	16,245	441,206
Lime	thousand short tons	1,545	26,055	1,528	30,036	1,434	36,540	1,456	39,686
Magnesium compounds from seawater and brine (except for metal)	short tons, MgO equivalant	455,501	41,790	503,281	53,302	W	W	W	W
Natural gas	million cubic feet	44,579	17,495	69,133	34,843	102,113	64,740	119,262	106,739
Natural gas liquids:									
Natural gasoline	thousand 42-gallon barrels	372	1,189	466	3,089	656	3,294	3,504	19,725
LP gases	do	691	2,529	849	5,383	1,348	5,945	1,215	6,306
Peat	thousand short tons	232	2,172	244	3,811	245	3,206	300	3,714
Petroleum (crude)	thousand 42-gallon barrels	14,614	59,413	18,021	154,746	24,420	262,352	30,421	329,637
Salt	thousand short tons	4,818	53,732	4,445	62,055	4,020	68,353	4,219	79,740
Sand and gravel	do	62,407	73,972	60,027	82,617	47,051	73,397	47,403	78,455
Silver (recoverable content of ores, etc.)	thousand troy ounces	850	2,175	643	3,028	632	2,795	311	1,352
Stone	thousand short tons	45,886	60,494	47,479	72,748	39,946	73,800	41,485	82,331
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, iodine, and values indicated by W		XX	40,392	XX	54,411	XX	116,223	XX	125,441
Total		XX	789,022	XX	1,035,430	XX	1,291,653	XX	1,543,516
MINNESOTA									
Clays	thousand short tons	[3]156	[3]233	W	W	W	W	W	W
Gem stones		NA	14	NA	14	NA	14	NA	15
Iron ore (usable)	thousand long tons, gross weight	62,614	782,197	59,422	949,678	49,167	1,015,272	47,874	1,137,733
Lime	short tons	W	W	W	W	W	W	103,389	2,794
Manganiferous ore (5% to 35% Mn)	short tons, gross weight	170,971	W	225,560	W	108,749	W	202,271	W
Peat	thousand short tons	W	W	20	471	13	230	26	1,505
Sand and gravel	do	37,935	39,438	36,720	42,370	33,398	45,214	[5]33,486	[5]44,503
Stone	do	7,581	20,411	8,301	22,041	6,854	23,302	7,567	25,767
Value of items that cannot be disclosed: Abrasive stones, cement (1973-75), clays (selected, 1973), lime, sand and gravel (industrial, 1976), and values indicated by W		XX	10,492	XX	11,792	XX	13,056	XX	5,713
Total		XX	852,785	XX	1,026,366	XX	1,097,088	XX	1,218,030

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
MISSISSIPPI								
Clays thousand short tons	2,075	$9,082	2,013	$10,468	1,592	$10,605	[3]1,487	[3]$8,849
Lime do	W	W	70	1,393	53	1,060	57	1,248
Natural gas million cubic feet	99,706	22,846	78,787	23,242	74,345	36,875	70,762	50,241
Petroleum (crude) thousand 42-gallon barrels	56,102	213,747	50,779	309,753	46,614	310,346	46,072	328,957
Sand and gravel thousand short tons	14,251	17,383	14,939	19,487	14,372	23,098	[5]12,033	[5]20,394
Stone do	[4]760	[4]809	1,719	2,572	1,629	2,730	1,762	2,968
Value of items that cannot be disclosed: Cement, clays (selected, 1976), magnesium compounds, natural gas liquids, sand and gravel (industrial, 1976), stone (limestone 1973), and values indicated by W	XX	17,871	XX	24,240	XX	25,295	XX	37,205
Total	XX	281,738	XX	391,155	XX	410,009	XX	449,862
MISSOURI								
Barite thousand short tons	196	3,395	177	3,386	171	3,989	124	3,860
Cement:								
Masonry do	84	2,400	75	2,434	65	2,110	76	2,718
Portland do	4,582	99,858	4,229	106,985	3,962	116,260	4,353	142,976
Clays do	2,551	11,626	[3]2,565	13,151	[3]21,68	[3]13,214	[3]2,133	[3]14,915
Coal (bituminous) do	4,658	24,999	4,623	29,383	5,638	48,054	6,075	56,934
Copper (recoverable content of ores, etc.) short tons	10,273	12,224	12,665	19,580	14,258	18,308	11,050	15,382
Iron ore (usable) thousand long tons, gross weight	2,630	W	1,866	W	2,273	W	2,133	W
Lead (recoverable content of ores, etc.) short tons	487,143	158,711	562,097	252,944	515,958	221,862	500,991	231,458
Lime thousand short tons	1,626	23,534	1,901	36,369	1,606	40,630	1,731	49,907
Natural gas million cubic feet	33	8	33	10	30	10	29	10
Petroleum (crude) thousand 42-gallon barrels	60	W	56	W	57	W	61	W
Phosphate rock thousand short tons	42	W	35	W	35	W	W	W
Sand and gravel do	10,879	16,950	10,933	19,462	9,752	18,216	15,375	26,550
Silver (recoverable content of ores, etc.) thousand troy ounces	2,058	5,264	2,387	11,244	2,525	11,161	2,277	9,905
Stone thousand short tons	49,304	79,921	50,626	90,204	46,988	95,535	47,546	98,327
Zinc (recoverable content of ores, etc.) short tons	82,350	34,027	91,987	66,047	74,867	58,396	85,530	61,812
Value of items that cannot be disclosed: Asphalt (native), clays (selected, 1974-75), and values indicated by W	XX	39,717	XX	39,850	XX	74,983	XX	70,406
Total	XX	512,634	XX	691,049	XX	722,728	XX	785,160

MONTANA								
Antimony, short tons	W	W	W	W	273	813	150	318
Clays[3], thousand short tons	219	1,298	298	2,189	223	1,878	192	W
Coal (bituminous and lignite), do.	10,725	30,238	14,106	54,961	22,054	111,579	26,231	128,534
Copper (recoverable content of ores, etc.), short tons	132,466	157,634	131,131	202,728	87,959	112,940	91,111	126,827
Gem stones	NA	150	NA	400	NA	400	NA	170
Gold (recoverable content of ores, etc.), troy ounces	27,806	2,720	28,268	4,516	17,259	2,787	24,075	3,017
Iron ore (usable), thousand long tons, gross weight	13	W	30	W	18	W	18	W
Lead (recoverable content of ores, etc.), short tons	176	57	154	69	205	88	92	43
Lime, thousand short tons	210	3,028	226	3,364	221	5,188	224	5,980
Manganese ore and concentrate (35% or more Mn), short tons, gross weight	239	W	--	--	--	--	--	--
Natural gas, million cubic feet	56,175	13,240	54,873	13,883	40,734	17,638	42,563	18,941
Peat, thousand short tons	1	W	W	W	1	51	W	W
Petroleum (crude), thousand 42-gallon barrels	34,620	115,423	34,554	229,802	32,844	257,169	32,814	276,419
Sand and gravel, thousand short tons	11,694	13,819	4,242	6,126	4,127	6,963	4,786	7,336
Silver (recoverable content of ores, etc.), thousand troy ounces	4,350	11,127	3,512	16,542	2,617	11,565	3,279	14,262
Stone, thousand short tons	5,054	9,559	[4]3,115	[4]6,242	[4]3,130	[4]6,753	3,468	7,994
Zinc (recoverable content of ores, etc.), short tons	73	30	136	98	110	86	64	47
Value of items that cannot be disclosed: Barite (1975-76), cement, fluorspar, gypsum, natural gas liquids, phosphate rock, pumice (1976), stone (dimension, 1974-75), talc (1973-76), tungsten ore and concentrate, vermiculite, and values indicated by W	XX	26,962	XX	33,881	XX	37,252	XX	46,401
Total	XX	385,285	XX	574,801	XX	573,150	XX	636,289
NEBRASKA								
Clays, thousand short tons	158	286	182	414	195	416	149	345
Gem stones	NA	11	NA	11	NA	11	NA	11
Lime, thousand short tons	31	651	36	591	W	W	W	W
Natural gas, million cubic feet	3,836	698	2,538	863	2,565	1,388	2,511	1,288
Petroleum (crude), thousand 42-gallon barrels	7,240	28,035	6,611	45,167	6,120	55,133	6,182	55,551
Sand and gravel, thousand short tons	15,906	18,366	13,231	17,727	11,759	16,901	[5]14,230	[5]21,483
Stone, do.	5,368	10,958	4,630	10,364	4,242	10,322	4,101	11,054
Value of items that cannot be disclosed: Cement, natural gas liquids, sand and gravel (industrial, 1976), and values indicated by W	XX	21,816	XX	23,497	XX	27,734	XX	33,633
Total	XX	80,821	XX	98,634	XX	111,905	XX	123,365
NEVADA								
Barite, thousand short tons	549	4,691	761	8,115	[r]947	[r]11,533	900	18,379
Clays, do.	36	176	39	218	[3]5	[3]136	[3]7	[3]174

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
NEVADA—Continued								
Copper (recoverable content of ores, etc.) short tons	93,702	$111,505	84,101	$130,021	81,210	$104,274	58,160	$80,958
Gem stones	NA	142	NA	400	NA	2,814	NA	1,300
Gold (recoverable content of ores, etc.) troy ounces	260,437	25,473	298,754	47,723	332,814	53,746	287,962	36,087
Gypsum thousand short tons	1,154	3,662	843	2,959	558	2,375	792	3,884
Iron ore (usable) thousand long tons, gross weight	119	W	139	W	109	1,017	W	W
Lead (recoverable content of ores, etc.) short tons	--	--	1,785	803	2,976	1,280	582	269
Mercury 76-pound flasks	698	200	W	W	W	W	22,837	2,770
Petroleum (crude) thousand 42-gallon barrels	96	W	129	W	115	W	143	W
Pumice thousand short tons	W	W	W	W	W	W	388	763
Sand and gravel do	12,448	14,614	8,736	14,515	8,056	16,848	9,671	20,106
Silver (recoverable content of ores, etc.) thousand troy ounces	624	1,595	872	4,108	1,609	7,111	784	3,410
Stone thousand short tons	3,595	5,429	2,186	4,203	[4]1,829	[4]4,524	[4]1,904	[4]5,975
Tungsten ore and concentrate thousand pounds contained W	150	377	132	537	33	152	99	561
Zinc (recoverable content of ores, etc.) short tons	--	--	3,405	2,445	5,496	4,287	1,438	1,064
Value of items that cannot be disclosed: Antimony (1973-74), cement, clays (selected, 1975-76), diatomite, fluorspar, lime, lithium minerals, magnesite, molybdenum, perlite, salt, stone (dimension, 1975-76), talc, and values indicated by W	XX	33,949	XX	41,829	XX	48,820	XX	57,983
Total	XX	201,813	XX	257,876	XX	[r]258,917	XX	233,683
NEW HAMPSHIRE								
Clays thousand short tons	43	64	34	55	W	W	W	W
Gem stones	NA	42	NA	42	NA	W	NA	W
Sand and gravel thousand short tons	7,795	8,597	6,126	8,223	5,150	9,077	[5]6,180	[5]10,409
Stone do	1,836	5,416	590	5,371	1,519	7,938	742	7,032
Value of items that cannot be disclosed	--	--	--	--	XX	92	XX	138
Total	XX	14,119	XX	13,691	XX	17,107	XX	17,579
NEW JERSEY								
Clays thousand short tons	183	666	104	524	67	372	61	331
Gem stones	NA	16	NA	16	NA	16	NA	17
Peat thousand short tons	44	514	31	603	29	686	22	568
Sand and gravel do	19,040	43,098	17,924	47,292	13,012	39,640	12,420	39,439
Stone[4] do	15,902	45,585	15,749	52,456	11,821	42,381	11,234	39,012
Zinc (recoverable content of ores, etc.) short tons	33,027	13,647	32,848	23,585	31,105	24,262	33,767	24,987

Value of items that cannot be disclosed: Lime (1973, 1976), magnesium compounds, manganiferous residuum, greensand marl, stone (dimension), and titanium concentrate	XX	10,490	XX	16,272	XX	16,345	XX	15,532
Total	XX	114,016	XX	140,748	XX	123,702	XX	119,886
NEW MEXICO								
Carbon dioxide ... million cubic feet	W	W	W	W	569,352	60	856,548	80
Clays[3] ... thousand short tons	88	169	55	317	44	61	56	116
Coal (bituminous) ... do	9,069	31,862	9,392	W	8,785	W	9,760	W
Copper (recoverable content of ores, etc.) ... short tons	204,742	243,643	196,585	303,920	146,263	187,802	172,360	239,925
Gem stones	NA	70	NA	200	NA	200	NA	210
Gold (recoverable content of ores) ... troy ounces	13,864	1,356	15,427	2,464	15,049	2,430	15,198	1,905
Gypsum ... thousand short tons	255	1,220	157	532	W	W	W	W
Helium (high-purity) ... million cubic feet	--	--	--	--	W	W	W	W
Iron ore (usable) ... thousand long tons, gross weight	5	114	6	135	W	W	W	W
Lead (recoverable content of ores, etc.) ... short tons	2,556	833	2,364	1,064	1,931	830	W	W
Lime ... thousand short tons	44	793	58	1,679	W	W	W	W
Manganiferous ore (5% to 35% Mn) ... short tons, gross weight	32,084	W	47,348	W	49,976	W	45,326	W
Mica, scrap ... thousand short tons	10	82	12	60	W	W	W	W
Natural gas ... million cubic feet	1,218,749	287,889	1,244,779	390,861	1,217,430	493,059	1,230,976	695,501
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	9,848	32,449	9,713	53,545	9,194	45,292	9,490	51,369
LP gases ... do	29,652	74,427	30,271	120,781	30,214	122,065	32,654	180,577
Peat ... thousand short tons	3	50	4	111	--	--	--	--
Perlite ... do	478	5,024	480	6,306	429	6,400	481	8,403
Petroleum (crude) ... thousand 42-gallon barrels	100,986	414,041	98,695	712,578	95,063	788,073	92,130	814,419
Potassium salts ... thousand short tons, K_2O equivalent	2,168	91,996	2,102	128,588	2,081	179,924	2,083	165,354
Pumice ... thousand short tons	339	1,001	471	1,466	397	1,280	486	1,560
Salt ... do	W	W	167	W	147	1,048	W	W
Sand and gravel ... do	10,641	15,753	7,413	10,605	6,220	13,798	7,702	16,671
Silver (recoverable content of ores, etc.) ... thousand troy ounces	1,111	2,843	1,195	5,628	792	3,501	892	3,880
Stone ... thousand short tons	2,830	5,894	[4]3,581	[4]8,359	2,197	4,683	1,935	4,394
Uranium (recoverable content of U_3O_8) ... thousand pounds	9,286	60,356	9,971	104,693	10,393	127,829	11,880	191,271
Zinc (recoverable content of ores, etc) ... short tons	12,327	5,094	13,784	9,897	11,015	8,592	W	W
Value of items that cannot be disclosed: Cement, clay (fire), fluorspar (1974-75), molybdenum, stone (dimension, 1974), tin, vanadium, and values indicated by W	XX	29,631	XX	77,755	XX	104,614	XX	134,492
Total	XX	1,306,590	XX	1,941,544	XX	2,091,541	XX	2,510,127
NEW YORK								
Clays[3] ... thousand short tons	1,799	2,146	1,451	2,348	817	1,561	649	2,089

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
NEW YORK—Continued								
Emery ---- short tons	2,883	W	W	W	W	W	W	W
Gem stones	NA	$16	NA	$16	NA	$16	NA	$15
Gypsum ---- thousand short tons	525	3,369	364	2,942	W	W	W	W
Lead (recoverable content of ores, etc.) ---- short tons	2,304	751	3,076	1,384	3,027	1,302	3,196	1,476
Natural gas ---- million cubic feet	4,539	1,590	4,990	2,745	7,628	5,645	9,235	10,436
Peat ---- thousand short tons	11	166	18	181	22	377	32	684
Petroleum (crude) ---- thousand 42-gallon barrels	967	5,412	896	9,538	875	10,693	857	10,497
Salt ---- thousand short tons	5,202	42,364	6,464	57,705	5,978	57,344	6,495	66,441
Sand and gravel ---- do	29,544	41,396	30,614	46,652	22,158	44,064	27,881	56,132
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	54	139	64	304	56	248	49	214
Stone ---- thousand short tons	44,393	94,693	38,207	87,724	31,713	80,929	28,136	75,040
Zinc (recoverable content of ores, etc.) ---- short tons	81,455	33,657	93,077	66,829	76,612	59,757	73,671	54,517
Value of items that cannot be disclosed: Cement, clay (ball), garnet (abrasive), iron ore, lime, mercury (1974-75), talc, titanium concentrate, wollastonite, and values indicated by W	XX	150,167	XX	162,205	XX	135,792	XX	150,423
Total	XX	375,866	XX	440,573	XX	397,728	XX	427,964
NORTH CAROLINA								
Clays[2] ---- thousand short tons	4,109	5,057	3,422	4,648	2,582	4,094	2,750	4,677
Feldspar ---- short tons	523,595	8,820	650,684	11,147	r468,401	r7,905	515,477	11,549
Gem stones	NA	40	NA	50	NA	50	NA	75
Mica:								
Scrap ---- thousand short tons	106	4,423	76	3,679	75	3,265	70	3,793
Sheet ---- pounds	--	--	W	W	W	W	5,000	2
Sand and gravel ---- thousand short tons	15,897	19,327	12,784	20,844	8,169	15,610	9,049	18,287
Stone ---- do	38,782	80,065	34,762	75,142	28,308	69,327	30,877	82,462
Talc and pyrophyllite ---- short tons	95,833	1,094	110,978	993	r95,575	r1,605	113,754	1,087
Value of items that cannot be disclosed: Asbestos, cement, clay (kaolin), iron ore (1973-74), lithium minerals, olivine, phosphate rock, and values indicated by W	XX	28,104	XX	39,366	XX	51,479	XX	81,407
Total	XX	146,930	XX	155,869	XX	r153,335	XX	203,339
NORTH DAKOTA								
Coal (lignite) ---- thousand short tons	6,906	14,328	7,463	16,351	8,515	27,010	11,102	41,507
Gem stones	NA	2	NA	2	NA	2	NA	2

Natural gas million cubic feet	27,703	5,457	31,206	6,210	24,786	5,701	31,470	10,699
Peat short tons	--	--	240	W	W	W	W	W
Petroleum (crude) thousand 42-gallon barrels	20,235	78,916	19,697	119,022	20,452	149,705	21,725	170,411
Sand and gravel thousand short tons	6,011	6,021	4,991	6,211	5,636	8,133	5,171	8,345
Stone do	W	W	35	115	30	153	--	--
Value of items that cannot be disclosed: Clays, lime, natural gas liquids, salt, and values indicated by W	XX	7,129	XX	11,516	XX	10,800	XX	13,141
Total	XX	111,853	XX	159,427	XX	201,504	XX	244,105
OHIO								
Cement:								
Masonry thousand short tons	176	5,641	158	5,227	136	4,576	155	7,288
Portland do	3,456	73,362	2,884	73,815	2,364	70,268	2,130	65,656
Clays do	4,732	12,456	4,325	13,488	3,451	11,822	4,288	14,704
Coal (bituminous) do	45,783	338,792	45,409	559,519	46,770	766,875	46,582	773,699
Gem stones	NA	8	NA	8	NA	W	NA	W
Lime thousand short tons	4,389	77,028	4,171	93,695	3,482	95,136	3,788	114,299
Natural gas million cubic feet	93,610	39,786	92,055	44,371	84,960	59,982	88,891	90,491
Peat thousand short tons	4	64	5	74	4	99	3	121
Petroleum (crude) thousand 42-gallon barrels	8,796	44,690	9,088	89,348	9,578	113,917	9,994	117,655
Salt thousand short tons	4,657	41,643	5,029	49,089	5,083	54,651	5,052	66,332
Sand and gravel do	48,987	69,982	41,353	68,258	37,195	68,552	38,876	76,730
Stone do	[4]55,107	[4]98,009	[4]51,709	[4]105,098	46,303	108,580	42,699	106,996
Value of items that cannot be disclosed: Abrasive stone, gypsum, stone (dimension, 1973-74), and values indicated by W	XX	5,518	XX	5,680	XX	1,996	XX	1,925
Total	XX	806,979	XX	1,107,670	XX	1,356,454	XX	1,435,896
OKLAHOMA								
Clays thousand short tons	[3]1,298	[3]1,871	1,289	2,105	995	1,701	1,155	1,678
Coal (bituminous) do	2,183	16,779	2,356	24,759	2,872	47,946	3,635	58,102
Gypsum do	1,429	5,796	1,225	5,622	1,028	4,835	1,120	5,822
Helium:								
High-purity million cubic feet	181	6,335	169	5,915	224	7,411	243	7,686
Crude do	115	1,380	134	1,608	148	1,776	181	2,172
Lead (recoverable content of ores, etc.) short tons	--	--	W	W	--	--	W	W
Natural gas million cubic feet	1,770,980	334,110	1,638,942	458,904	1,605,410	513,731	1,726,513	866,710
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	14,674	49,070	12,581	84,638	10,835	63,383	10,894	74,416
LP gases do	29,044	95,264	31,231	166,461	29,640	140,197	31,620	179,602
Petroleum (crude) do	191,204	723,273	177,785	1,277,076	163,123	1,389,164	161,426	1,484,297
Pumice thousand short tons	1	W	W	W	1	W	1	W
Salt do	5	36	W	W	W	W	W	W
Sand and gravel do	12,154	14,941	8,708	13,772	9,591	16,749	10,037	[3]19,050
Stone do	22,316	34,999	22,228	36,599	20,111	36,840	19,635	37,339

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
OKLAHOMA—Continued								
Zinc (recoverable content of ores, etc.) ....short tons	--	--	W	W	--	--	W	W
Value of items that cannot be disclosed: Cement, clay (bentonite, 1973), copper (1973-75), feldspar (1974, 1976), lime, silver (1973-75), tripoli, and values indicated by the W	XX	$39,772	XX	$45,142	XX	$43,362	XX	$53,100
Total	XX	1,323,626	XX	2,122,601	XX	2,267,095	XX	2,789,974
OREGON								
Clays ....thousand short tons	168	291	140	243	120	214	147	315
Copper ....short tons	W	W	W	W	W	W	--	--
Gem stones	NA	700	NA	500	NA	500	NA	525
Gold (recoverable content of ores, etc.) ....troy ounces	W	W	W	W	W	W	28	4
Lead (recoverable content of ores, etc.) ....short tons	--	--	W	W	W	W	--	--
Lime ....thousand short tons	106	2,552	98	2,818	96	3,281	W	W
Nickel (content of ore and concentrate) ....short tons	18,272	W	16,618	W	16,987	W	16,469	W
Pumice ....thousand short tons	1,171	2,013	915	1,887	1,470	3,937	1,125	2,311
Sand and gravel ....do	22,802	32,751	18,558	30,948	16,527	29,596	[5]17,554	[5]33,473
Silver (recoverable content of ores, etc.) ....thousand troy ounces	1	3	9	42	W	W	--	--
Stone ....thousand short tons	13,411	21,843	23,353	43,406	21,275	40,321	20,349	42,686
Value of items that cannot be disclosed: Cement, diatomite, emery (1975), mercury (1973), sand and gravel (industrial, 1976), talc and soapstone, tungsten (1976), and values indicated by W	XX	21,424	XX	24,076	XX	28,155	XX	33,252
Total	XX	81,577	XX	103,920	XX	106,004	XX	112,566
PENNSYLVANIA								
Cement:								
Masonry ....thousand short tons	490	14,443	404	14,642	357	14,640	379	16,903
Portland ....do	8,563	171,653	7,448	191,594	5,815	168,220	5,989	185,170
Clays[3] ....do	2,975	16,664	2,732	16,496	1,945	13,672	2,291	16,037
Coal:								
Anthracite ....do	6,830	90,260	6,617	144,695	6,203	198,481	6,228	209,233
Bituminous ....do	76,403	786,792	80,462	1,637,394	84,137	2,111,009	85,777	2,173,009
Copper (recoverable content of ores, etc.) ....short tons	1,845	2,195	--	--	--	--	W	W

Gem stones	NA	9	NA	9	NA	9	NA	9
Lime thousand short tons	2,260	40,949	2,080	50,147	1,940	60,047	2,069	68,356
Mica, scrap do	--	--	--	--	W	W	W	W
Natural gas million cubic feet	78,514	32,976	82,637	36,360	84,676	57,156	89,386	61,229
Peat thousand short tons	28	411	30	515	27	488	W	W
Petroleum (crude) thousand 42-gallon barrels	3,282	18,440	3,478	36,220	3,264	39,647	3,019	36,700
Sand and gravel thousand short tons	20,576	42,830	18,071	45,181	17,401	48,742	19,038	55,611
Stone do	78,564	150,346	73,092	159,615	60,177	149,670	63,607	165,889
Zinc (recoverable content of ores, etc.) short tons	18,857	7,792	20,288	14,567	21,090	16,450	22,280	16,487
Value of items that cannot be disclosed: Clay (kaolin), iron ore, natural gas liquids, tripoli, and values indicated by W	XX	26,140	XX	26,993	XX	29,607	XX	36,553
Total	XX	1,401,900	XX	2,374,428	XX	2,907,838	XX	3,041,186
RHODE ISLAND								
Sand and gravel thousand short tons	2,429	3,095	2,784	4,605	2,910	5,070	W	W
Stone do	W	W	W	W	293	1,125	W	W
Value of items that cannot be disclosed: Other nonmetals and values indicated by W	XX	1,245	XX	1,377	XX	3	XX	6,400
Total	XX	4,340	XX	5,982	XX	6,198	XX	6,400
SOUTH CAROLINA								
Clays thousand short tons	[3]2,250	[3]12,877	[3]2,297	[3]13,765	[3]1,698	[3]12,828	2,270	17,288
Gem stones	NA	5	NA	5	NA	5	NA	4
Mica (scrap) thousand short tons	W	W	W	252	7	318	W	W
Peat do	14	W	18	W	18	W	15	W
Sand and gravel do	8,179	12,628	7,380	13,054	7,363	14,128	7,887	17,154
Stone do	14,985	24,280	[4]12,242	[4]21,719	13,836	30,082	13,027	30,690
Value of items that cannot be disclosed: Cement, clay (fullers earth, 1973-75), manganiferous ore (1975-76), stone (crushed, 1974), vermiculite, and values indicated by W	XX	38,571	XX	56,376	XX	[r]58,107	XX	60,319
Total	XX	88,361	XX	105,171	XX	[r]115,468	XX	125,455
SOUTH DAKOTA								
Clays[3] thousand short tons	201	181	190	202	187	185	124	137
Gem stones	NA	42	NA	42	NA	42	NA	44
Gold (recoverable content of ores, etc.) troy ounces	375,575	34,974	343,723	54,906	304,935	49,244	318,511	39,916
Gypsum thousand short tons	W	W	32	135	23	60	W	W

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
SOUTH DAKOTA—Continued								
Lime thousand short tons	63	$1,206	94	$2,059	W	W	W	W
Mica (scrap) do	--	--	W	W	W	W	--	--
Petroleum (crude) thousand 42-gallon barrels	275	988	494	3,283	472	$5,996	447	$5,519
Sand and gravel thousand short tons	13,963	16,587	9,028	9,720	6,481	8,668	5,763	8,057
Silver (recoverable content of ores, etc.) thousand troy ounces	72	184	62	294	68	299	58	253
Stone thousand short tons	2,745	11,607	2,968	14,231	2,647	15,350	3,241	17,240
Value of items that cannot be disclosed: Beryllium concentrate (1975-76), cement, clay (bentonite), feldspar, iron ore (1974-76), natural gas liquids (1974-76), and values indicated by W	XX	15,370	XX	17,938	XX	21,977	XX	30,364
Total	XX	81,139	XX	102,810	XX	101,821	XX	101,530
TENNESSEE								
Barite thousand short tons	W	W	W	W	13	260	W	W
Cement:								
Masonry do	201	7,908	154	4,706	138	4,778	175	6,476
Portland do	1,711	42,402	1,525	43,339	1,136	37,866	1,256	43,495
Clays[3] do	1,719	9,083	1,638	9,776	1,310	9,008	1,530	11,578
Coal (bituminous) do	8,219	66,827	7,541	135,874	8,206	140,293	9,283	151,372
Copper (recoverable content of ores, etc.) short tons	8,500	10,115	6,304	9,745	10,041	12,893	11,131	15,494
Gold (recoverable content of ores, etc.) troy ounces	68	7	18	3	W	W	W	W
Lime thousand short tons	W	W	136	3,449	106	3,735	W	W
Natural gas million cubic feet	20	6	17	6	27	12	47	24
Petroleum (crude) thousand 42-gallon barrels	201	W	769	7,256	682	7,849	598	8,203
Phosphate rock thousand short tons	2,512	12,799	2,411	18,465	2,291	28,803	1,801	14,527
Sand and gravel do	12,010	20,145	10,702	19,476	10,909	22,102	11,096	25,129
Silver (recoverable content of ores, etc.) thousand troy ounces	73	187	20	94	54	238	78	339
Stone thousand short tons	42,742	71,116	41,720	75,547	r38,439	r81,187	37,600	86,156
Zinc (recoverable content of ores, etc.) short tons	64,172	26,516	85,671	61,512	83,293	64,968	82,512	61,059
Value of items that cannot be disclosed: Clays (selected), pyrites, and values indicated by W	XX	8,579	XX	6,360	XX	8,526	XX	15,862
Total	XX	275,690	XX	395,608	XX	r422,518	XX	439,714
TEXAS								
Cement:								
Masonry thousand short tons	234	6,606	195	6,438	181	7,089	213	10,596
Portland do	8,320	189,368	7,739	207,706	7,195	224,804	7,388	271,066

Clays ... do	5,667	13,115	5,315	13,677	4,248	13,411	[3]3,706	[3]8,847
Coal (lignite) ... do	6,944	W	7,684	W	11,002	W	14,063	W
Gem stones	NA	163	NA	160	NA	160	NA	168
Gypsum ... thousand short tons	1,616	6,469	1,365	5,276	1,094	4,277	1,531	6,322
Helium (crude) ... million cubic feet	904	10,848	35	420	36	432	12	144
Iron ore ... thousand long tons	W	W	W	W	601	W	566	W
Lime ... thousand short tons	1,677	26,887	1,835	39,644	1,735	46,179	1,455	43,983
Natural gas ... million cubic feet	8,513,850	1,735,221	8,170,798	2,541,118	7,485,764	3,885,112	7,191,859	5,163,755
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	92,743	347,393	88,316	629,529	78,835	479,700	77,578	560,831
LP gases ... do	221,686	589,685	213,756	1,004,653	212,635	965,363	209,514	1,223,562
Perlite ... short tons	602	W	--	--	--	--	--	--
Petroleum (crude) ... thousand 42-gallon barrels	1,294,671	5,157,623	1,262,126	8,773,003	1,221,929	9,336,570	1,189,523	10,217,702
Salt ... thousand short tons	10,354	45,350	11,379	51,296	8,560	42,119	9,718	48,875
Sand and gravel ... do	38,546	60,706	42,466	81,364	38,649	87,106	47,848	103,217
Stone ... do	62,574	91,379	[4]63,074	[4]109,758	57,985	106,554	54,856	101,652
Sulfur (Frasch process) ... thousand long tons	4,109	W	4,473	W	3,406	W	3,415	W
Talc and soapstone ... short tons	232,514	1,246	188,262	1,310	129,626	795	199,663	1,071
Value of items that cannot be disclosed: Asphalt (native), clays (selected, 1976), fluorspar, graphite, magnesium chloride (for metal), magnesium compounds (except for metal), mercury (1973), sodium sulfate, stone (dimension, 1974), uranium, and values indicated by W	XX	160,435	XX	245,792	XX	[r]325,701	XX	381,418
Total	XX	8,442,494	XX	13,711,144	XX	[r]15,525,372	XX	18,143,204
UTAH								
Carbon dioxide, natural ... thousand cubic feet	80,490	6	93,571	6	108,941	8	21,875	2
Clays ... thousand short tons	[3]243	[3]771	232	953	[3]220	[3]548	[3]206	[3]531
Coal (bituminous) ... do	5,500	61,566	5,858	71,699	6,961	138,134	7,967	182,712
Copper (recoverable content of ores, etc.) ... short tons	256,589	305,341	230,593	356,497	177,155	227,467	185,458	258,157
Fluorspar ... do	4,778	144	2,967	98	9,542	389	W	W
Gem stones	NA	95	NA	100	NA	100	NA	105
Gold (recoverable content of ores, etc.) ... troy ounces	307,080	30,035	254,909	40,719	189,620	30,622	187,318	23,475
Gypsum ... thousand short tons	231	1,134	248	1,076	247	1,457	270	1,657
Iron ore (usable) ... thousand long tons, gross weight	1,986	13,581	1,808	14,016	1,334	10,399	W	W
Lead (recoverable content of ores, etc.) ... short tons	13,733	4,474	10,510	4,729	12,679	5,452	16,297	7,529
Lime ... thousand short tons	185	3,804	176	4,911	161	4,540	202	6,855
Natural gas ... million cubic feet	42,715	8,159	50,522	20,815	55,354	26,570	57,416	28,995
Petroleum (crude) ... thousand 42-gallon barrels	32,656	117,743	39,363	279,858	42,301	348,131	34,304	318,911
Pumice ... thousand short tons	42	57	15	19	17	23	164	264
Salt ... do	717	6,913	771	7,321	631	7,717	705	10,090
Sand and gravel ... do	15,410	15,986	11,578	12,985	10,159	14,342	[5]10,547	[5]13,442
Silver (recoverable content of ores, etc.) ... thousand troy ounces	3,619	9,257	3,208	15,109	2,822	12,472	3,134	13,633
Stone ... thousand short tons	2,848	6,318	2,869	6,410	2,486	6,167	2,751	7,009

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
UTAH—Continued								
Uranium (recoverable content of U_3O_8) .... thousand pounds	1,961	$12,745	W	W	W	W	W	W
Vanadium (recoverable in ore and concentrate) .... short tons	142	W	W	W	W	W	W	W
Zinc (recoverable content of ores, etc.) .... do	16,800	6,942	12,619	$9,060	19,640	$15,319	22,481	$16,636
Value of items that cannot be disclosed: Asphalt (gilsonite), beryl concentrate, cement, clays (kaolin, except 1974), magnesium chloride (1973-75), magnesium compounds, molybdenum, natural gas liquids, phosphate rock, potassium salts, sand and gravel (industrial, 1976), sodium sulfate, tungsten, and values indicated by W	XX	69,274	XX	105,664	XX	116,550	XX	153,978
Total	XX	[r]674,345	XX	952,045	XX	966,407	XX	1,043,981
VERMONT								
Peat .... thousand short tons	([6])	2	([6])	4	([6])	W	--	--
Sand and gravel .... do	4,041	3,581	2,394	3,588	2,356	3,693	[5]2,379	[5]3,758
Stone .... do	1,871	19,523	1,932	21,630	1,224	15,718	1,978	22,443
Talc .... short tons	251,087	1,497	W	W	230,973	1,918	252,371	1,685
Value of items that cannot be disclosed: Asbestos, other nonmetals, and values indicated by W	XX	4,763	XX	8,723	XX	7,450	XX	7,211
Total	XX	29,366	XX	33,945	XX	28,779	XX	35,097
VIRGINIA								
Clays .... thousand short tons	1,646	1,886	1,957	2,614	819	1,152	862	1,210
Coal (bituminous) .... do	33,961	377,679	34,326	856,099	35,510	1,081,587	39,996	964,669
Gem stones	NA	13	NA	13	NA	13	NA	12
Lead (recoverable content of ores, etc.) .... short tons	2,637	859	3,106	1,398	2,551	1,097	1,946	899
Lime .... thousand short tons	782	12,205	895	18,929	705	20,192	878	25,993
Natural gas .... million cubic feet	5,101	1,688	7,096	3,619	6,723	3,462	6,937	7,908
Petroleum (crude) .... thousand 42-gallon barrels	--	--	3	W	3	W	3	W
Sand and gravel .... thousand short tons	14,511	26,246	14,314	29,270	9,895	24,776	[5]10,191	[5]23,089
Soapstone .... short tons	4,600	12	W	W	W	W	W	W
Stone .... thousand short tons	43,895	82,719	44,176	95,988	35,384	84,204	36,132	91,723
Zinc (recoverable content of ores, etc.) .... short tons	16,683	6,894	17,195	12,346	15,151	11,818	11,214	8,319
Value of items that cannot be disclosed: Aplite, cement, gypsum, kyanite, sand and gravel (industrial, 1976), silver (1975-76), and values indicated by W	XX	35,201	XX	36,293	XX	33,673	XX	36,823

Total	XX	545,402	XX	1,056,569	XX	1,261,974	XX	1,160,645
WASHINGTON								
Cement:								
Masonry ---- thousand short tons	6	169	6	193	5	209	6	334
Portland ---- do	1,194	26,651	1,377	36,347	1,147	40,666	1,238	48,669
Clays[3] ---- do	287	664	269	698	290	778	381	1,141
Coal (bituminous) ---- do	3,270	21,440	3,913	W	3,743	W	4,109	W
Gem stones	NA	160	NA	160	NA	160	NA	168
Lead (recoverable content of ores, etc.) ---- short tons	2,217	722	1,299	585	W	W	W	W
Peat ---- thousand short tons	21	110	14	85	13	98	14	103
Pumice ---- do	1	1	(6)	1	--	--	--	--
Sand and gravel ---- do	27,935	30,132	22,842	35,030	19,069	32,990	19,813	36,017
Stone ---- do	11,384	19,284	15,095	24,483	7,920	18,754	10,223	24,091
Zinc (recoverable content of ores, etc.) ---- short tons	6,378	2,635	6,909	4,960	W	W	W	W
Values of items that cannot be disclosed: Clay (fire), copper, diatomite, gold, gypsum, lime, olivine, silver, talc, tungsten, uranium, and values indicated by W	XX	12,695	XX	41,388	XX	64,850	XX	76,699
Total	XX	114,663	XX	143,930	XX	158,505	XX	187,222
WEST VIRGINIA								
Clays[3] ---- thousand short tons	348	516	339	520	278	439	275	463
Coal (bituminous) ---- do	115,448	1,340,338	102,462	2,218,418	109,283	3,206,951	108,834	3,278,180
Gem stones	NA	2	NA	2	NA	2	NA	2
Natural gas ---- million cubic feet	208,676	64,481	202,306	66,356	154,484	57,005	153,322	87,394
Petroleum (crude) ---- thousand 42-gallon barrels	2,385	11,965	2,665	27,058	2,479	29,712	2,519	30,227
Salt ---- thousand short tons	1,217	6,082	1,201	6,296	972	r4,671	1,118	W
Sand and gravel ---- do	5,893	16,257	5,382	16,018	5,068	17,872	[5]4,337	[5]11,006
Stone ---- do	[4]11,732	[4]22,821	10,954	22,308	[4]10,583	[4]24,333	[4]9,717	[4]24,133
Value of items that cannot be disclosed: Cement (masonry and portland), clays (fire clay), lime, natural gas liquids, sand and gravel (industrial, 1976), and values indicated by W	XX	40,583	XX	r46,201	XX	49,226	XX	66,596
Total	XX	1,503,045	XX	2,403,177	XX	r3,390,211	XX	3,498,001
WISCONSIN								
Clays ---- thousand short tons	2	3	2	4	2	4	W	W
Gem stones	NA	1	NA	1	NA	1	NA	1
Iron ore (usable) ---- thousand long tons, gross weight	956	W	899	W	791	W	664	W
Lead (recoverable content of ores, etc.) ---- short tons	844	275	1,285	578	W	W	W	W
Lime ---- thousand short tons	310	6,004	311	6,764	296	8,604	325	10,058
Peat ---- do	2	208	W	W	11	502	11	W
Sand and gravel ---- do	40,250	43,647	28,850	34,577	30,057	40,580	30,879	42,001

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State —Continued

Mineral	1973 Quantity	1973 Value (thousands)	1974 Quantity	1974 Value (thousands)	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
WISCONSIN—Continued								
Stone ---- thousand short tons	23,818	$36,917	22,443	$40,912	20,566	$40,156	20,739	$41,338
Zinc (recoverable content of ores, etc.) ---- short tons	8,672	3,583	8,737	6,273	W	W	W	W
Value of items that cannot be disclosed: Abrasive stones, cement, copper (1974-75), silver (1974-75), and values indicated by the W	XX	23,701	XX	25,654	XX	42,413	XX	39,055
Total	XX	114,339	XX	114,763	XX	132,260	XX	132,453
WYOMING								
Clays ---- thousand short tons	2,343	24,043	2,511	29,339	2,582	36,046	2,697	40,015
Coal (bituminous) ---- do	14,886	60,939	20,703	103,915	23,804	160,447	30,836	215,936
Feldspar ---- short tons	2,588	56	W	W	W	W	W	W
Gem stones	NA	142	NA	140	NA	140	NA	147
Gypsum ---- thousand short tons	312	1,348	315	960	271	902	317	1,280
Iron ore (usable) ---- thousand long tons, gross weight	2,070	W	2,105	W	2,039	26,792	2,139	29,461
Lime ---- thousand short tons	30	548	29	464	W	W	W	W
Natural gas ---- million cubic feet	357,731	64,749	326,657	80,031	316,123	106,533	328,768	134,795
Natural gas liquids:								
Natural gasoline ---- thousand 42-gallon barrels	3,351	10,647	2,933	18,577	2,909	17,694	3,044	19,866
LP gases ---- do	7,237	22,507	6,804	31,707	6,061	29,578	6,681	35,677
Petroleum (crude) ---- do	141,914	541,820	139,997	914,360	135,943	983,785	134,149	971,235
Sand and gravel ---- thousand short tons	6,201	11,635	5,532	9,508	4,328	10,746	5,470	10,782
Stone ---- do	3,191	6,716	2,384	[4]5,989	2,882	7,618	2,757	7,630
Uranium (recoverable content of U_3O_8) ---- thousand pounds	10,134	65,868	7,449	78,213	6,862	84,406	8,064	129,823
Value of items that cannot be disclosed: Cement, phosphate rock, pumice (1973), sodium carbonate, and values indicated by W	XX	117,565	XX	163,997	XX	179,751	XX	254,952
Total	XX	928,583	XX	1,437,200	XX	1,644,438	XX	1,851,599

[r]Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain cement, included with "Value of items that cannot be disclosed."
[3]Excludes certain clays, included with "Value of items that cannot be disclosed."
[4]Excludes certain stones, included with "Value of items that cannot be disclosed."
[5]Excludes industrial sand and gravel, included with "Value of items that cannot be disclosed."
[6]Less than 1/2 unit.
[7]Total of items listed.
[8]Excludes salt in brine, included with "Value of items that cannot be disclosed."

Table 7.—Mineral production[1] in the islands administered by the United States

(Thousand short tons and thousand dollars)

Area and mineral	1973		1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
American Samoa:								
Pumice	37	214	27	183	15	15	47	30
Stone	63	152	50	122	34	147	30	156
Total	XX	366	XX	305	XX	162	XX	186
Guam: Stone	1,246	3,139	798	1,444	781	1,837	457	1,438
Virgin Islands: Stone	664	2,860	638	3,869	253	1,813	279	2,050

XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Table 8.—Mineral production[1] in the Commonwealth of Puerto Rico

(Thousand short tons and thousand dollars)

Mineral	1973		1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Cement	2,062	41,203	1,881	70,277	1,582	60,968	1,558	66,150
Clays	464	473	291	332	341	440	W	W
Lime	42	2,215	39	2,923	28	2,231	28	2,513
Salt	29	580	29	624	27	639	27	639
Sand and gravel	7,480	21,243	NA	NA	NA	NA	NA	NA
Stone	15,647	41,857	14,362	41,640	13,595	47,515	13,404	47,124
Total	XX	107,571	XX	[2]115,796	XX	[2]111,793	XX	[2]116,426

NA Not available. W Withheld to avoid disclosing individual company confidential data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Total does not include value of items withheld or not available.

Table 9.—U.S. exports of principal minerals and products

Mineral	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
METALS				
Aluminum:				
Ingots, slabs, crude short tons	185,850	$134,064	152,366	$118,644
Scrap do	[r]66,937	[r]29,169	108,958	63,245
Plates, sheets, bars, etc do	171,008	228,684	203,843	261,759
Castings and forgings do	5,008	18,813	5,611	21,232
Aluminum sulfate do	47,688	2,897	50,758	1,569
Other aluminum compounds do	835,920	131,726	911,460	166,084
Antimony, metals and alloys, crude do	[r]339	348	341	853
Bauxite, including bauxite concentrates thousand long tons	19	1,651	15	1,297
Beryllium pounds	37,336	1,152	114,143	1,756
Bismuth, metals and alloys do	[1]128,893	[1]636	[1]68,488	[1]514
Cadmium thousand pounds	396	589	504	713
Calcium:				
Carbonate short tons	4,640	705	3,411	735
Chloride do	28,359	2,314	33,533	2,578
Dicalcium phosphate do	21,053	6,270	32,302	7,612
Chrome:				
Ore and concentrates:				
Exports thousand short tons	139	6,896	124	5,609
Reexports do	45	2,111	85	5,475
Ferrochrome do	13	9,075	14	8,785
Cobalt thousand pounds	4,237	14,881	3,892	12,427
Columbium metals, alloys, other forms do	53	787	67	778
Copper:				
Ore, concentrate, composition metal, and unrefined (copper content) short tons	16,451	14,454	22,689	19,769
Scrap do	45,002	40,793	37,473	37,079
Refined copper and semimanufactures do	258,165	465,553	176,877	313,377
Other copper manufactures do	9,518	14,158	4,923	8,435
Copper sulfate or blue vitriol do	1,248	2,067	2,071	2,935
Copper-base alloys do	130,254	179,838	110,665	177,270
Ferroalloys:				
Ferrosilicon do	39,712	15,732	12,416	7,449
Ferrophosphorus do	437	57	1,636	153
Gold:				
Ore and base bullion troy ounces	393,970	63,654	337,517	41,624
Bullion, refined do	3,101,812	429,278	3,193,248	333,424
Iron ore thousand long tons	2,537	60,071	2,913	82,192
Iron and steel:				
Pig iron short tons	59,596	4,636	57,480	5,408
Iron and steel products (major):				
Semimanufactures do	1,690,956	633,502	1,856,573	592,126
Manufactures and steel mill products do	2,284,043	2,336,341	1,814,776	1,870,281
Iron and steel scrap: Ferrous scrap, including rerolling materials thousand short tons	9,642	780,984	8,168	636,758
Slag short tons	139,516	5,506	38,718	1,264
Lead:				
Pigs, bars, anodes, sheets, etc short tons	21,256	12,041	5,877	5,320
Scrap do	49,951	10,063	46,883	11,539
Magnesium, metal and alloys, scrap, semimanufactured forms, n.e.c. do	32,591	48,191	13,444	26,902
Manganese:				
Ore and concentrate do	204,523	13,886	127,971	7,510
Ferromanganese do	[r]32,487	[r]10,743	6,789	3,462
Metal do	3,256	3,318	4,654	3,434
Mercury:				
Exports 76-pound flasks	339	152	501	306
Reexports do	155	68	12	6
Molybdenum:				
Ore and concentrates (molybdenum content) thousand pounds	62,611	159,592	62,474	183,536
Metals and alloys, crude and scrap do	317	858	223	390
Wire do	270	2,863	343	3,672
Semimanufactured forms, n.e.c do	312	1,790	184	1,584
Powder do	60	296	25	136
Ferromolybdenum do	2,241	4,798	3,596	9,447
Nickel:				
Alloys and scrap (including Monel metal), ingots, bars, sheets, etc short tons	23,118	102,400	38,143	141,724
Catalysts do	3,536	13,713	4,442	16,282
Nickel-chrome electric resistance wire do	679	4,769	769	5,253
Semifabricated forms, n.e.c do	2,788	20,420	4,207	30,736
Platinum:				
Ore, concentrate, metal and alloys in ingots, bars, sheets, anodes, other forms, including scrap troy ounces	376,450	56,412	325,805	37,868
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap) do	283,435	31,102	186,602	14,885

See footnotes at end of table.

Table 9.—U.S. exports of principal minerals and products —Continued

Mineral	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
METALS —Continued				
Platinum —Continued				
Platinum-group manufactures, except jewelry	NA	$3,246	NA	$2,977
Rare earths:				
Cerium ore, metal, alloys lighter flints pounds	100,279	300	119,792	335
Silicon:				
Ferrosilicon short tons	[r]39,712	[r]15,732	12,416	7,449
Silicon carbide, crude and in grains do	12,970	6,839	10,106	6,174
Silver:				
Ore, concentrates, waste, sweepings thousand troy ounces	10,005	43,481	7,000	28,849
Bullion, refined do	22,621	104,086	7,596	32,586
Tantalum:				
Ore, metal, other forms thousand pounds	531	5,545	213	6,711
Powder do	161	5,974	110	7,982
Tin:				
Ingots, pigs, bars, etc.:				
Exports metric tons	[r]1,444	10,457	540	2,998
Reexports do	[r]2,152	15,531	1,798	13,967
Tin scrap and other tin-bearing material except tinplate scrap do	5,062	4,343	6,927	7,391
Titanium:				
Ore and concentrate short tons	3,147	505	4,802	477
Sponge (including iodide titanium and scrap) do	4,326	7,630	6,144	8,547
Intermediate mill shapes and mill products, n.e.c. do	1,900	24,726	1,065	15,039
Dioxide and pigments do	15,807	12,110	20,580	16,229
Tungsten, ore and concentrates:				
Exports thousand pounds	1,316	8,082	1,729	11,189
Reexports do	316	930	887	1,903
Uranium:				
Ores and concentrates (U_3O_8 content) pounds	122,663	1,840	1,495,130	24,432
Metal do	14,840	203	7,108	146
Compounds do	3,837,266	52,040	369,036	7,232
Isotopes (stable) and their compounds	NA	2,679	NA	2,103
Radioactive materials thousand curies	37,850,386	20,088	31,474,488	25,905
Special nuclear materials	NA	236,849	NA	426,423
Vanadium:				
Ore and concentrate, pentoxide, etc. (vanadium content) pounds	430,592	1,628	197,035	742
Ferrovanadium do	2,035,851	7,952	2,421,776	9,180
Zinc:				
Slabs, pigs, or blocks short tons	6,897	5,870	3,513	2,306
Sheets, plates, strips, other forms n.e.c do	1,629	2,086	2,271	2,817
Waste, scrap, and dust (zinc content) do	5,051	2,448	8,945	3,535
Semifabricated forms, n.e.c do	14,196	9,379	9,320	6,076
Zirconium:				
Ore and concentrate pounds	37,531,345	4,787	18,855,595	2,784
Metals, alloys, other forms do	2,649,694	[r]25,828	2,304,202	43,809
NONMETALS				
Abrasives:				
Dust and powder of precious or semiprecious stones, including diamond dust and powder thousand carats	12,802	32,088	14,155	35,450
Crushing bort do	3	12	77	182
Industrial diamonds do	950	5,948	639	3,677
Diamond grinding wheels do	684	4,933	730	4,911
Other natural and artificial metallic abrasives and products	NA	59,868	NA	68,979
Asbestos:				
Exports:				
Unmanufactured short tons	34,921	10,059	46,317	12,640
Products do	NA	60,556	NA	60,276
Reexports:				
Unmanufactured do	1,526	608	606	151
Products do	NA	220	NA	296
Barite:				
Natural barium sulfate do	57,386	1,868	41,063	2,871
Lithopone do	1,833	1,060	779	937
Boron:				
Boric acid do	33,697	11,532	36,492	12,363
Sodium borates, refined do	212,266	42,486	211,362	49,156
Cement do	494,132	28,409	466,055	26,601
Clays:				
Kaolin or china clay do	878,619	47,905	839,230	57,649
Fire clay do	219,431	7,191	296,016	12,895

See footnotes at end of table.

Table 9.—U.S. exports of principal minerals and products —Continued

Mineral	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
NONMETALS —Continued				
Clays —Continued				
Other clays ---- short tons	1,216,088	$65,202	1,351,953	$81,409
Feldspar, leucite nepheline syenite - thousand pounds	19,087	507	12,289	352
Fluorspar ---- short tons	1,355	194	4,923	764
Gem stones:				
Diamonds ---- thousand carats	265	236,988	313	306,098
Pearls	NA	413	NA	581
Other	NA	25,480	NA	30,896
Graphite ---- short tons	10,586	1,890	79,098	6,753
Gypsum:				
Crude, crushed or calcined -- thousand short tons	75	4,505	284	6,739
Manufactures, n.e.c	NA	5,976	NA	25,855
Lithium hydroxide ---- thousand pounds	1,226	1,593	534	674
Kyanite and allied minerals ---- short tons	150,369	9,355	63,329	4,942
Lime ---- do	53,853	2,746	55,852	2,981
Magnesium compounds:				
Magnesite, dead-burned ---- thousand pounds	165,309	14,146	142,745	13,466
Magnesite, crude, caustic calcined, lump or ground -- do	18,195	4,538	20,242	5,422
Mica sheet, waste and scrap, and ground ---- pounds	10,977,353	3,154	14,449,150	3,477
Mica, manufactured ---- do	1,132,301	3,950	2,481,151	3,776
Mineral-earth pigments, iron oxide, natural and manufactured ---- short tons	13,231	7,710	11,867	11,387
Nitrogen compounds (major) --- thousand short tons	[r]4,736	[r]860,110	4,714	449,147
Phosphate rock ---- do	12,606	461,553	11,019	327,410
Phosphatic fertilizers:				
Superphosphates ---- do	[r]1,166	[r]192,898	1,334	110,835
Ammonium phosphates ---- do	2,422	532,274	2,406	269,855
Elemental phosphorus ---- short tons	35,845	36,659	29,038	30,387
Mixed chemical fertilizers -- thousand short tons	324	40,695	42	30,284
Pigments and compounds (lead and zinc):				
Lead oxides:				
Pigment grade ---- short tons	1,695	901	2,620	1,661
Other grade ---- do	580	490	345	438
Zinc oxides:				
Pigment grade ---- do	2,389	1,867	4,261	2,587
Other grade ---- do	715	496	577	524
Zinc compounds ---- do	917	1,060	779	937
Potash:				
Fertilizer ---- do	1,419,317	[1]92,701	1,669,691	91,887
Chemical ---- do	104,497	18,949	60,025	19,422
Pumice and pumicite ---- thousand pounds	2,504	1,027	2,022	271
Quartz, natural, quartzite, cryolite, chiolite short tons	1,767	1,106	--	--
Salt:				
Crude and refined ---- thousand short tons	1,332	9,070	1,007	10,326
Shipments to noncontiguous territories --- do	20	2,304	18	2,230
Sand and gravel:				
Sand:				
Construction ---- short tons	510,859	1,111	558,733	1,337
Industrial ---- do	2,171,109	13,071	2,553,475	17,080
Gravel ---- do	537,290	864	579,359	1,099
Sodium and sodium compounds:				
Sodium sulfate ---- do	77	6,144	57	3,636
Sodium carbonate ---- do	529	45,822	645	49,781
Stone:				
Dolomite, block ---- do	49	1,464	63	1,486
Limestone, crushed, ground, broken ---- do	3,386	9,993	3,191	10,537
Marble and other building and monumental do	NA	2,449	NA	2,596
Stone, crushed, ground, broken thousand short tons	896	5,843	866	7,073
Manufactures of stone ---- do	NA	2,376	NA	2,273
Sulfur:				
Crude ---- thousand long tons	1,288	69,553	1,183	60,226
Crushed, ground flowers of ---- do	7	2,248	15	3,358
Talc, crude and ground ---- short tons	157,681	6,338	212,344	9,034
MINERAL FUELS				
Carbon black ---- thousand pounds	87,947	15,474	110,760	27,231
Coal:				
Anthracite ---- thousand short tons	640	25,801	615	24,008
Bituminous ---- do	65,669	3,232,893	59,406	2,886,467
Briquets ---- do	90	9,566	87	10,998
Coke ---- do	1,273	74,732	1,315	66,726
Natural gas ---- thousand cubic feet	105,879,552	114,275	95,866,953	140,854
Petroleum:				
Crude ---- thousand barrels	19	187	2,227	27,129
Gasoline ---- do	185	3,103	266	5,592
Jet fuel ---- do	326	3,459	348	3,404
Naphtha ---- do	1,168	27,271	2,608	37,045
Kerosine ---- do	28	437	33	504
Distillate oil ---- do	92	1,156	97	1,333

See footnotes at end of table.

Table 9.—U.S. exports of principal minerals and products —Continued

Mineral	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
MINERAL FUELS —Continued				
Petroleum —Continued				
Residual oil thousand barrels	4,892	$43,179	3,438	$32,301
Lubricating oil do	8,827	300,873	6,749	206,681
Asphalt do	245	6,222	262	8,051
Liquefied petroleum gases do	9,432	100,041	8,967	98,981
Wax do	581	27,502	605	30,997
Coke do	36,949	315,239	38,315	352,523
Petrochemical feedstocks do	7,436	95,681	6,885	91,491
Miscellaneous do	1,088	43,976	1,016	46,366
Total	XX	[r]14,345,654	XX	12,514,499

[r]Revised. NA Not available.
[1]Adjusted by the Bureau of Mines.

Table 10.—U.S. imports for consumption of principal minerals and products

Mineral	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
METALS				
Aluminum:				
Metal ---- short tons	434,119	$316,873	575,350	$439,570
Scrap ---- do	54,806	27,586	85,714	46,166
Plates, sheets, bars, etc ---- do	61,354	65,079	87,560	96,312
Aluminum oxide (alumina) ---- do	3,507,415	370,039	3,624,367	404,478
Anitimony:				
Ore (antimony content) ---- do	8,320	14,535	10,023	16,911
Needle or liquated ---- do	74	255	41	129
Metal ---- do	2,112	5,677	2,083	4,986
Oxide ---- do	9,908	12,588	11,611	17,029
Arsenic:				
White (As_2O_3 content) ---- do	12,013	4,426	4,262	1,528
Metallic ---- do	483	2,716	288	1,735
Bauxite, crude ---- thousand long tons	[r]11,529	NA	12,548	NA
Beryllium ore ---- short tons	[1]1,479	[1]468	1,058	380
Bismuth ---- pounds	1,331,173	9,442	2,328,051	14,154
Cadmium:				
Metal ---- short tons	2,618	13,902	3,411	14,511
Flue dust (cadmium content) ---- do	346	1,489	246	536
Calcium:				
Metal ---- pounds	70,128	78	461,965	475
Chloride ---- short tons	12,021	598	16,046	480
Chrome:				
Ore and concentrates (Cr_2O_3 content) thousand short tons	559	60,651	533	70,075
Ferrochrome ---- do	198	190,630	150	124,819
Metal ---- do	2	6,630	2	9,142
Cobalt:				
Metal ---- thousand pounds	6,092	25,611	15,129	66,299
Oxide (gross weight) ---- do	233	779	138	573
Salts and compounds (gross weight) ---- do	41	74	235	365
Columbium ore ---- do	1,542	2,012	3,968	5,737
Copper (copper content):				
Ore and concentrates ---- short tons	29,301	35,649	35,197	49,861
Regulus, black, coarse ---- do	5,675	20,560	14,097	54,878
Unrefined, black, blister ---- do	78,969	90,846	19,388	22,144
Refined in ingots, etc ---- do	142,945	166,159	381,343	453,279
Old and scrap ---- do	14,399	14,459	19,735	19,231
Ferroalloys, n.e.c ---- do	[r]61,946	[r]35,556	99,905	47,430
Gallium ---- kilograms	6,830	3,555	4,920	2,326
Gold (general imports):				
Ore and base bullion ---- troy ounces	313,038	50,055	166,312	20,007
Bullion ---- do	2,348,936	406,583	2,489,679	311,011
Indium ---- do	113,800	629	290,139	1,802
Iron ore ---- thousand long tons	46,743	860,496	44,390	980,348
Iron and steel:				
Pig iron ---- short tons	478,106	69,316	444,282	51,142
Iron and steel products (major):				
Iron products ---- do	47,535	32,299	44,877	32,002
Steel products ---- do	12,440,326	4,475,191	13,051,471	4,479,191
Scrap ---- do	293,082	24,464	495,584	34,524
Tinplate ---- do	12,277	786	11,581	596
Lead:				
Ore, flue dust, matte (lead content) ---- do	45,024	12,329	88,988	29,492
Base bullion (lead content) ---- do	462	183	2,334	955
Pigs and bars (lead content) ---- do	99,054	46,703	141,980	60,245
Reclaimed scrap, etc. (lead content) ---- do	1,741	617	2,644	1,022
Sheet, pipe, shot ---- do	147	99	294	495
Magnesium:				
Metallic and scrap ---- do	6,787	9,299	13,066	19,020
Alloys (magnesium content) ---- do	1,111	2,215	1,820	3,604
Sheets, tubing, ribbons, wire, other forms (magnesium content) ---- do	5	33	21	38
Manganese:				
Ore (35% or more contained manganese) ---- do	765,530	77,103	649,245	73,627
Ferromanganese (manganese content) ---- do	306,650	128,381	417,433	164,698
Metal ---- do	4,378	4,041	7,082	5,258
Mercury:				
Compounds ---- pounds	[r]6,112	[r]42	35,536	90
Metal ---- 76-pound flasks	43,865	7,599	44,415	4,325
Minor metals: Selenium and salts ---- pounds	889,320	10,265	811,257	12,118
Molybdenum:				
Ore (content) ---- do	2,556,680	5,916	2,092,623	4,850
Waste and scrap ---- do	44,672	101	297,554	1,183
Metal ---- do	38,926	434	63,500	705,274
Compounds ---- do	682,039	745	679,289	690
Nickel:				
Pigs, ingots, shot, cathodes ---- short tons	107,084	406,894	111,255	456,398
Plates, bars, etc ---- do	[r]1,752	11,118	3,223	20,348
Slurry ---- do	23,991	63,522	33,280	98,178
Scrap ---- do	2,353	5,864	2,359	4,827
Powder and flakes ---- do	9,772	39,413	10,181	45,267
Ferronickel ---- do	65,046	67,818	55,721	72,161
Oxide ---- do	5,063	15,172	5,932	21,948

See footnotes at end of table.

Table 10.—U.S. imports for consumption of principal minerals and products —Continued

Mineral	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
METALS —Continued				
Platinum-group metals:				
Unwrought:				
Grains and nuggets (platinum) troy ounces	19,253	$2,941	596	$88
Sponge (platinum) do	567,466	91,567	904,048	139,378
Sweepings, waste, scrap do	116,523	14,278	146,773	20,080
Iridium do	14,419	6,892	18,179	5,045
Palladium do	409,862	33,863	994,360	48,535
Rhodium do	80,197	34,400	62,260	18,342
Ruthenium do	16,535	926	75,673	3,580
Other platinum-group metals do	234,757	37,055	224,560	32,195
Semimanufactured:				
Platinum do	96,630	15,337	95,653	15,623
Palladium do	144,240	15,163	128,951	6,325
Rhodium do	1,832	675	1,864	382
Other platinum-group metals do	118,570	19,726	14,142	1,963
Radium: Radioactive substitutes	NA	8,297	NA	12,200
Rare-earth metals, ferrocerium, other cerium alloys pounds	33,852	187	40,259	167
Silicon (silicon content):				
Metal short tons	3,852	6,591	[2]1,359	[2]6,170
Ferrosilicon do	47,365	41,950	64,124	39,808
Silver (general imports):				
Ore and base bullion thousand troy ounces	21,197	87,755	16,717	70,206
Bullion do	61,629	274,254	67,187	289,032
Sweepings, waste, dore do	7,596	32,527	4,454	18,823
Tantalum ore thousand pounds	[r]1,753	[r]7,794	2,557	15,124
Tin:				
Ore (tin content) metric tons	[r]6,415	44,114	5,733	38,529
Blocks, pigs, grains, etc do	[r]44,366	312,346	45,055	325,453
Dross, skimmings, scrap, residue, and tin alloys, n.s.p.f do	[r]2,468	2,452	2,666	3,550
Tinfoil, powder, flitters, etc	NA	7,257	NA	8,148
Titanium:				
Ilmenite[3] short tons	334,692	15,903	431,717	18,715
Rutile do	224,499	46,362	281,712	54,849
Metal pounds	10,549,619	18,332	7,922,050	12,690
Ferrotitanium do	1,071,048	1,125	1,798,936	1,438
Compounds and mixtures do	53,964,945	19,654	140,795,246	53,806
Tungsten (tungsten content):				
Ore and concentrate thousand pounds	6,570	31,665	5,301	28,320
Waste and scrap do	71	317	170	694
Other alloys do	1,898	11,104	2,473	14,255
Ferrotungsten do	418	2,542	844	5,451
Uranium and other uranium-bearing and nuclear materials:				
Oxide U_3O_8 do	2,451,538	24,481	11,074,298	203,926
Compounds, n.e.c do	19,226,578	161,507	33,876,908	441,603
Isotopes (stable) and their compounds	NA	957	NA	1,067
Radio isotopes, elements, etc thousand curies	35,346,036	8,297	60,302,966	12,200
Vanadium (content):				
Ferrovanadium thousand pounds	273	1,435	518	2,448
Vanadium-bearing materials (vanadium pentoxide content) do	8,185	7,075	10,702	7,721
Zinc:				
Ore (zinc content) short tons	428,544	108,822	155,803	50,553
Blocks, pigs, slabs do	374,922	273,636	695,131	482,265
Sheets, etc do	236	507	209	329
Old, dross, skimmings do	3,158	1,238	12,445	4,884
Dust, powder, flakes do	5,739	5,744	6,009	5,134
Manufactures	NA	79	NA	96
Zirconium:				
Ore, including zirconium sand short tons	40,205	8,874	64,643	13,733
Unwrought, scrap, and compounds do	2,013	5,991	914	1,153
NONMETALS				
Abrasives:				
Diamonds (industrial) thousand carats	14,291	53,383	17,047	61,102
Other abrasives	NA	[r]68,480	NA	96,130
Asbestos short tons	538,553	111,011	657,851	142,145
Barite:				
Crude and ground do	672,528	9,264	917,812	17,829
Witherite do	85	44	278	56
Chemicals do	10,937	4,443	16,913	5,095
Boron:				
Carbide pounds	137,572	[r]645	30,232	240
Boric acid do	345,237	[r]59	112,870	14
Calcium borate, crude do	55,282,329	[r]1,560	60,493,065	1,953
Cement thousand short tons	3,702	70,620	3,107	67,085
Clays:				
Raw short tons	33,851	1,644	34,359	1,207
Manufactured do	4,143	303	4,309	607
Cryolite do	22,120	9,058	11,325	4,329

See footnotes at end of table.

Table 10.—U.S. imports for consumption of principal minerals and products —Continued

Mineral	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
NONMETALS —Continued				
Feldspar:				
Crude ---- short tons	[1]209	$17	93	$17,614
Ground and crushed ---- do	81	6	--	--
Fluorspar ---- do	1,050,448	61,059	895,254	56,580
Gem stones:				
Diamond ---- thousand carats	4,577	722,119	6,716	1,011,839
Emeralds ---- do	806	40,348	1,165	55,286
Other	NA	87,963	NA	112,241
Graphite ---- short tons	65,663	5,698	79,098	6,753
Gypsum:				
Crude, ground, calcined ---- thousand short tons	5,450	16,193	6,253	18,285
Manufactures	NA	3,617	NA	3,468
Iodine, crude ---- thousand pounds	5,309	11,721	6,482	13,824
Kyanite ---- short tons	65	3	110	12
Lime:				
Hydrated ---- do	44,637	1,392	48,461	1,814
Other ---- do	214,311	4,867	316,442	8,816
Lithium:				
Ore ---- do	4,548	538	68	1
Compounds ---- do	11	107	48	621
Magnesium compounds:				
Crude magnesite ---- do	10	1	18	2
Lump, ground, caustic-calcined magnesia ---- do	5,716	502	8,194	808
Refractory magnesia, dead-burned, fused magnesite, dead-burned dolomite ---- do	156,332	24,668	88,035	14,518
Compounds ---- do	36,572	1,796	27,039	2,267
Mica:				
Uncut sheet and punch ---- thousand pounds	904	696	1,654	941
Scrap ---- do	10,672	356	4,210	202
Manufactures ---- do	5,075	2,935	3,328	3,193
Mineral-earth pigments, iron oxide pigments:				
Ocher, crude and refined ---- short tons	20	3	50	11
Siennas, crude and refined ---- do	521	107	624	122
Umber, crude and refined ---- do	4,251	350	6,908	561
Vandyke brown ---- do	319	57	739	147
Natural, other ---- do	1,001	223	1,231	190
Synthetic ---- do	21,867	8,444	40,547	15,523
Nepheline syenite:				
Crude ---- do	6,275	98	2,112	38
Ground, crushed, etc ---- do	424,838	6,869	499,135	8,785
Nitrogen compounds (major), including urea ---- thousand short tons	3,113	415,534	3,467	296,814
Phosphate, crude ---- do	37	1,604	51	2,234
Phosphatic fertilizers ---- do	147	26,970	47	6,631
Pigments and salts:				
Lead pigments and compounds ---- short tons	15,337	7,470	17,836	9,462
Zinc pigments and compounds ---- do	18,447	10,746	27,969	15,557
Potash ---- do	6,292,329	285,272	7,595,246	360,756
Pumice:				
Crude or unmanufactured ---- do	3,260	77	3,344	148
Wholly or partly manufactured ---- do	142,120	380	78,057	350
Manufactures, n.s.p.f	NA	76	NA	70
Quartz crystal (Brazilian pebble) ---- pounds	1,487,272	931	1,148,801	368
Salt ---- thousand short tons	3,215	15,272	4,352	23,476
Sand and gravel:				
Glass sand ---- do	45	475	61	484
Other sand and gravel ---- do	329	301	292	425
Sodium sulfate ---- do	285	12,624	316	16,111
Stone and whiting	NA	[r]46,137	NA	46,211
Strontium:				
Mineral ---- short tons	21,613	826	35,711	1,486
Compounds ---- do	3,100	1,261	5,370	2,334
Sulfur and compounds, sulfur ore and other forms, n.e.s. ---- thousand long tons	1,897	70,848	1,727	59,494
Talc, unmanufactured ---- short tons	23,378	1,471	20,071	1,861
MINERAL FUELS				
Carbon black:				
Acetylene ---- pounds	5,839,266	2,578	8,294,902	4,366
Gas black and carbon black ---- do	33,034,187	4,284	44,120,742	7,016
Coal:				
Bituminous, slack, culm, lignite ---- short tons	939,721	21,682	1,203,076	17,739
Briquets ---- do	16,367	270	18,829	434
Coke ---- do	1,818,981	156,488	1,311,472	111,066
Natural gas, ethane, methane, and mixtures thereof ---- thousand cubic feet	944,352,390	1,070,539	943,432,188	1,611,644
Peat:				
Fertilizer grade ---- short tons	283,732	23,371	332,433	28,939
Poultry and stable grade ---- do	6,626	488	5,618	553
Petroleum:				
Crude petroleum ---- thousand barrels	1,581,129	18,290,012	2,051,307	25,456,155
Distillate ---- do	39,420	489,351	22,023	270,707

See footnotes at end of table.

Table 10.—U.S. imports for consumption of principal minerals and products —Continued

Mineral	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
MINERAL FUELS —Continued				
Petroleum —Continued				
Residual ____ thousand barrels	362,084	$3,958,178	405,833	$4,372,317
Unfinished oils ____ do	1,514	18,042	5,686	74,934
Gasoline ____ do	22,740	314,971	8,073	130,373
Jet fuel ____ do	44,368	619,102	26,056	373,450
Motor fuels, n.e.s ____ do	666	8,799	1,019	12,178
Kerosine ____ do	46	511	(4)	2
Lubricants ____ do	130	4,159	547	5,491
Wax ____ do	157	6,128	164	5,212
Naphtha ____ do	64,654	782,485	51,112	702,583
Liquefied petroleum gases ____ do	41,171	354,947	47,528	396,035
Asphalt ____ do	4,835	52,274	4,388	46,022
Miscellaneous ____ do	21,285	248,453	18,372	256,230
Total ____	XX	r38,847,295	XX	48,718,321

rRevised. NA Not available. XX Not applicable.
1Adjusted by the Bureau of Mines.
2Does not include silicon metal more than 96% but less than 99% silicon.
3Includes titanium slag averaging about 70% TiO_2, for detail see Titanium chapter.
4Less than 1/2 unit.

Table 11.—Comparison of world and U. S. production of principal mineral commodities

(Thousand short tons unless otherwise specified)

Minerals	1975			1976[p]		
	World production[1]	U.S. production	U.S. percent of world production	World production[1]	U.S. production	U.S. percent of world production
MINERAL FUELS						
Carbon black ---- million pounds	6,937	2,742	40	7,726	3,004	39
Coal:						
Bituminous	[2]1,976,155	628,619	32	[2]2,018,657	653,055	32
Lignite	944,677	19,819	2	985,178	25,630	3
Pennsylvania anthracite	196,301	6,203	3	196,769	6,228	3
Coke (excluding breeze):						
Gashouse[3]	18,816	--	--	18,823	--	--
Oven and beehive	400,470	57,207	14	404,713	58,333	14
Natural gas (marketable) ---- million cubic feet	47,517,774	20,108,661	42	49,459,213	19,952,438	40
Peat	223,960	772	(4)	222,856	969	(4)
Petroleum (crude) ---- thousand barrels	19,497,604	3,052,048	16	21,187,147	2,971,686	14
NONMETALS						
Asbestos	4,564	99	2	5,566	115	2
Barite	5,358	1,318	25	5,457	1,234	23
Cement	774,277	[5]69,721	9	811,502	[5]74,495	9
Clay, china	15,969	[6]5,334	33	17,029	[6]6,115	36
Corundum	9	--	--	9	--	--
Diamond ---- thousand carats	41,108	--	--	39,726	--	--
Diatomite	1,830	573	31	1,905	631	33
Feldspar	2,893	670	23	2,850	740	26
Fluorspar	5,015	140	3	4,889	188	4
Graphite	486	W	NA	500	W	NA
Gypsum	62,855	9,751	16	66,231	11,980	18
Lime (sold or used)	113,637	[5]19,161	17	116,291	[5]20,257	17
Magnesite	11,147	W	NA	10,598	W	NA
Mica (including scrap) ---- thousand pounds	499,464	270,005	54	471,082	254,629	54
Nitrogen, agricultural[7]	46,722	[5]9,341	20	48,366	[5]10,210	21
Phosphate rock	118,254	48,816	41	117,898	49,241	42
Potash (K_2O equivalent)	27,352	2,501	9	26,876	2,400	9
Pumice[8]	17,059	3,907	23	17,553	4,181	24
Pyrites ---- thousand long tons	22,007	625	3	21,898	750	3
Salt	178,432	[5]41,057	23	183,252	[5]44,218	24
Strontium[8]	58	--	--	63	--	--
Sulfur, elemental ---- thousand long tons	49,877	11,259	23	49,741	10,706	22
Talc, pyrophyllite, soapstone	5,385	965	18	5,944	1,092	18
Vermiculite[8]	579	330	57	566	304	54

METALS, MINE BASIS							
Antimony (content of ore and concentrate)	short tons	76,700	886	1	76,286	283	(4)
Arsenic, white	do	46,449	W	NA	39,919	W	NA
Bauxite	thousand long tons	74,503	[9]1,772	2	76,337	[9]1,958	3
Beryl	short tons	3,608	W	NA	3,035	W	NA
Bismuth	thousand pounds	8,818	W	NA	9,262	W	NA
Chromite		9,071	--	--	9,492	--	--
Cobalt (contained)	short tons	32,462	--	--	28,681	--	--
Columbium-tantalum concentrate[8]	thousand pounds	33,354	--	--	50,845	--	--
Copper (content of ore and concentrate)		7,672	[10]1,413	18	8,213	[10]1,606	20
Gold	thousand troy ounces	38,676	1,052	3	39,883	1,048	3
Iron ore	thousand long tons	887,389	[11]78,866	9	881,028	[11]79,993	9
Lead (content of ore and concentrate)		3,750	621	17	3,701	610	16
Manganese ore (35% or more Mn)		27,076	--	--	27,292	--	--
Mercury	thousand 76-pound flasks	252	7	3	244	23	9
Molybdenum (content of ore and concentrate)	thousand pounds	176,713	105,980	60	191,287	113,233	59
Nickel (content of ore and concentrate)		868	17	2	886	16	2
Platinum-group metals	thousand troy ounces	5,714	19	(4)	5,992	6	(4)
Silver	do	297,882	34,938	12	304,899	34,328	11
Tin (content of ore and concentrate)	metric tons	224,180	W	NA	225,755	W	NA
Titanium concentrates:							
Ilmenite		3,218	717	22	3,512	652	19
Rutile[8]		417	W	NA	471	W	NA
Tungsten concentrate (contained tungsten)	thousand pounds	84,262	5,588	7	91,845	5,830	6
Uranium oxide (U_3O_8)[8]	short tons	26,677	11,600	43	30,100	12,700	42
Vanadium (content of ore and concentrate)	do	23,201	4,743	20	25,950	7,376	28
Zinc (content of ore and concentrate)		6,391	469	7	6,462	485	8

See footnotes at end of table.

Table 11.—Comparison of world and U. S. production of principal mineral commodities —Continued

(Thousand short tons unless otherwise specified)

Minerals	1975 World production[1]	1975 U.S. production	1975 U.S. percent of world production	1976[p] World production[1]	1976[p] U.S. production	1976[p] U.S. percent of world production
METALS, SMELTER BASIS						
Aluminum	13,352	3,879	29	13,774	4,251	31
Cadmium ____ short tons	16,925	[12]2,193	13	18,892	[12]2,256	12
Copper	7,793	[13]1,447	19	8,164	[13]1,535	19
Iron, pig	528,861	79,721	15	549,298	86,848	16
Lead	3,656	[14]636	17	3,788	[14]653	17
Magnesium	138	W	NA	148	W	NA
Selenium[8] ____ thousand pounds	2,561	358	14	2,773	401	14
Steel ingots and castings	712,556	[15]116,642	16	748,492	[15]128,000	17
Tellurium[8] ____ thousand pounds	315	131	42	NA	W	NA
Tin ____ metric tons	230,596	[16]6,500	3	228,856	[16]5,700	2
Zinc	5,592	438	8	5,978	499	8

[p]Preliminary. NA Not available. W Withheld to avoid to disclosing individual company confidential data.
[1]May not represent total world production because confidential U.S. data are excluded for some commodities. World totals include reported figures and reasonable estimates; however, for some commodities where data were not available, no reasonable estimates could be made and none have been included.
[2]Includes small quantities of lignite for People's Republic of China and Pakistan, and anthracite for Colombia.
[3]Includes low- and medium-temperature and gashouse coke.
[4]Less than 1/2 unit.
[5]Includes Puerto Rico.
[6]Kaolin sold or used by producers.
[7]Year ended June 30 of year stated (United Nations).
[8]World total exclusive of the U.S.S.R.
[9]Dry bauxite, equivalent of crude ore.
[10]Recoverable.
[11]Includes byproduct ore.
[12]Includes secondary.
[13]Smelter output from domestic and foreign ores, exclusive of scrap.
[14]Lead refined from domestic and foreign ores; excludes lead refined from imported base bullion.
[15]Data from American Iron and Steel Institute. Excludes production of castings by companies that do not produce steel ingot.
[16]Includes tin content of alloys made directly from ore.

Abrasive Materials

By W. T. Adams[1]

The production of natural abrasives varied in quantity and value compared with 1975. Output of tripoli-type materials and garnet increased in both quantity and value; special silica stone products decreased in quantity and increased in value; the production of emery decreased.

The production and value of manufactured abrasive materials increased for all types.

Table 1.—Salient abrasives statistics in the United States

Kind	1972	1973	1974	1975	1976
Natural abrasives (domestic) sold or used by producers:					
Tripoli (crude) short tons	87,864	101,519	85,121	80,562	124,281
Value thousands	$797	$929	$623	$565	$776
Special silicastone products[1] short tons	3,241	3,466	3,134	2,953	2,696
Value thousands	$670	r$667	$717	$1,061	$1,404
Garnet short tons	18,916	22,772	24,684	17,204	24,565
Value thousands	$1,957	$2,380	$2,551	$1,690	$2,740
Emery short tons	2,883	2,884	2,520	3,487	W
Value thousands	W	W	W	W	W
Artificial abrasives[2] short tons	584,680	[3]645,813	[3]730,405	[3]528,307	[3]620,328
Value thousands	$92,958	[3]$108,808	[3]$175,678	[3]$141,580	$176,064
Foreign trade (natural and artificial abrasives):					
Exports (value) do	$64,219	$82,969	$115,508	$102,849	$113,199
Reexports (value) do	$26,746	$29,413	$29,829	$28,362	$29,285
Imports for consumption (value) do	$106,512	$136,655	$142,974	r$121,863	$157,232

rRevised. W Withheld to avoid disclosing individual company confidential data.
[1]Includes grinding pebbles, grindstones, oilstones, tube-mill liners, and whetstones.
[2]Production of silicon carbide and aluminum oxide (the United States and Canada); shipments of metallic abrasives (the United States).
[3]Includes production of aluminum zirconium oxide (the United States and Canada).

FOREIGN TRADE

Imports of abrasive materials were 29% greater in value than in 1975, and exports plus reexports increased 9% in value. Net imports, the excess of imports over exports and reexports, were $14.7 million. The volume and value of all abrasive materials exported varied.

Industrial diamond imports totaled 17.0 million carats of loose material valued at $61.1 million, reflecting increases of 19% in quantity and 14% in value from those of 1975. Exports of loose industrial diamond were 14.9 million carats, an increase of 8%, and the value was $39.3 million, an increase of 3%. Reexports of similar industrial diamond were 3.1 million carats, a decrease of 4%, and the value was $28.9 million, an increase of 2%. The diamond content in diamond wheels, exported and reexported, was 749,000 carats, an increase of 8%, and

[1]Physical scientist, Division of Nonmetallic Minerals.

the declared value was $5.0 million, for no change in value. The imports of diamond wheels are listed by number and value; the value in 1976 increased to $1,302,000 from $896,000 in 1975.

The 1976 imports of industrial diamond from Ireland were 5.9 million carats valued at $13.9 million, reflecting increases of 31% in quantity and 33% in value from those of 1975. The share of imports from Ireland was 35% of the total quantity and 23% of the value. Of the industrial imported bort, powder, and dust, synthetic diamond was 4.5 million carats valued at $9.0 million and natural diamond was 6.9 million carats valued at $15.1 million.

Table 2.—U.S. exports of abrasive materials, by kind

(Thousands)

Kind	1975		1976	
	Quantity	Value	Quantity	Value
NATURAL ABRASIVES				
Dust and powder of natural and synthetic precious or semi-precious stones, including diamond dust and powder ___ carats__	12,802	$32,088	14,155	$35,450
Crushing bort, except dust and powder ___ do__	3	12	77	182
Industrial diamond ___ do__	950	5,948	639	3,677
Emery, natural corundum, and other natural abrasives, n.e.c ___ pounds__	21,366	4,138	33,619	6,189
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) ___ do__	[1]53,302	[1]13,638	43,682	14,820
Silicon carbide, crude or in grains ___ do__	25,939	6,839	20,212	6,174
Carbide abrasives, n.e.c ___ do__	1,324	4,533	1,919	5,331
Grinding and polishing wheels and stones:				
Diamond ___ carats__	684	4,933	730	4,911
Pulpstones ___ pounds__	2,991	1,476	1,109	657
Polishing stones, whetstones, oilstones, hones, and similar stone ___ do__	912	1,315	739	1,222
Wheels and stones, n.e.c ___	5,156	11,970	5,027	13,759
Abrasive paper and cloth, coated with natural or artificial abrasive materials ___ reams__	282	11,998	436	17,051
Coated abrasives, n.e.c ___	NA	3,961	NA	3,776
Total ___	XX	102,849	XX	113,199

NA Not available. XX Not applicable.
[1]Adjusted by the Bureau of Mines.

Table 3.—U. S. reexports of abrasive materials, by kind

(Thousands)

Kind	1975		1976	
	Quantity	Value	Quantity	Value
NATURAL ABRASIVES				
Dust and powder of natural and synthetic precious or semi-precious stones, including diamond dust and powder ___ carats__	435	$958	302	$744
Crushing bort, except dust and powder ___ do___	371	1,958	356	2,108
Industrial diamond ___ do___	2,425	25,294	2,438	26,027
Emery, natural corundum, and other natural abrasives, n.e.c ___ pounds__	5	3	2	6
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) ___ do___	63	5	129	38
Silicon carbide, crude or in grains ___ do___	--	--	([1])	2
Carbide abrasives, n.e.c ___ do___	--	--	7	90
Grinding and polishing wheels and stones:				
Diamond ___ carats__	8	49	19	122
Wheels and stones, n.e.c ___ pounds__	9	28	30	51
Abrasive paper and cloth, coated with natural or artificial abrasive materials ___ reams__	1	38	1	47
Coated abrasives, n.e.c ___	NA	29	NA	50
Total ___	XX	28,362	XX	29,285

NA Not available. XX Not applicable.
[1]Less than 1/2 unit.

Table 4.—U. S. imports for consumption of abrasive materials (natural and artificial), by kind

(Thousands)

Kind	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Corundum, crude ---------- short tons--	1	$81	2	$230
Emery, flint, rottenstone, and tripoli, crude or crushed ---------- do----	6	426	5	379
Silicon carbide, crude ---------- do----	85	16,544	89	21,191
Aluminum oxide, crude ---------- do----	128	24,273	174	37,628
Other crude artificial abrasives ---------- do----	2	411	1	198
Abrasives, ground grains, pulverized or refined:				
Rottenstone and tripoli ---------- do----	(1)	1	(1)	1
Silicon carbide ---------- do----	1	1,133	1	1,356
Aluminum oxide ---------- do----	3	1,635	5	2,059
Emery, corundum, flint, garnet, and other, including artificial abrasives ---------- do----	(1)	115	1	762
Papers, cloths, and other materials wholly or partly coated with natural or artificial abrasives ----------	(2)	17,140	(2)	24,492
Hones, whetstones, oilstones, and polishing stones ----- number--	210	138	207	194
Abrasive wheels and millstones:				
Burrstones manufactured or bound up into millstones ---------- short tons--	(1)	1	--	--
Solid natural stone wheels ---------- number--	3	19	10	18
Diamond ---------- do----	35	896	41	1,302
Abrasive wheels bonded with resins ---------- do----	1	2,376	1	3,270
Other ----------	(2)	2,083	(2)	2,255
Articles not especially provided for:				
Emery or garnet ----------	(2)	21	(2)	25
Natural corundum or artificial abrasive materials ----------	(2)	440	(2)	418
Other ----------	(2)	290	(2)	352
Diamond:				
Diamond dies ---------- number--	12	r457	--	--
Crushing bort ---------- carats--	283	668	186	402
Other industrial diamond ---------- do----	4,096	27,636	4,484	31,344
Miners' diamond ---------- do----	1,166	6,773	1,119	5,591
Dust and powder ---------- do----	8,746	18,306	11,258	23,765
Total ----------	XX	r121,863	XX	157,232

rRevised. XX Not applicable.
[1]Less than 1/2 unit.
[2]Quantity not reported.

TRIPOLI

Fine-grained, porous, silica materials are grouped together because they have similar properties and end uses. Production of crude tripoli increased 54% in quantity and 38% in value. Processed tripoli sold or used increased 67% in quantity and 62% in value. The uses for processed tripoli in 1976 were 60% for abrasives and 35% for fillers, compared with 57% and 41% respectively in 1975.

Tripoli producers in 1976 were Malvern Minerals Co., Garland County, Ark., which produced crude and finished material, Midwestern Minerals Corp., Ottawa County, Okla., which produced crude and finished material, and American Tripoli Co., Division of The Carborundum Co., which produced crude in Ottawa County, Okla., and finished material in Newton County, Mo. Illinois Minerals Co. and Tammsco, Inc., both in Alexander County, Ill., produced amorphous silica. Keystone Filler and Manufacturing Co., Northumberland County, Pa., mined and processed rottenstone. Prices quoted in Engineering and Mining Journal, December 1976, for tripoli and amorphous silica follow:

Tripoli, paper bags, carload lots, f.o.b., in cents per pound:	
White, Elco, Ill.: Air floated through 200 mesh ----------	1.6
Rose and cream, Seneca, Mo. and Rogers, Ark.:	
Once ground ----------	2.90
Double ground ----------	2.90
Air float ----------	3.15
Amorphous silica, bags, f.o.b., in dollars per ton:	
Elco, Ill:	
Through 200 mesh, 90% to 95% -----	$31
Through 200 mesh, 96% to 99% -----	32
Through 325 mesh, 96% to 98% -----	37
Through 325 mesh, 98% to 99.4% ----	35.50
Through 325 mesh, 99.5% ----------	51.50
Through 400 mesh, 99.9% ----------	75
Below 15 micrometers, 99% ----------	82.50
Below 10 micrometers, 99% ----------	105
Dierks, Ark.:	
200 mesh ----------	40
325 mesh ----------	50

Table 5.—Processed tripoli[1] sold or used by producers in the United States, by use[2]

Use		1972	1973	1974	1975	1976
Abrasives	short tons	47,321	55,420	50,615	38,815	68,874
Value	thousands	$1,918	$2,233	$2,251	$1,518	$2,525
Filler	short tons	25,973	32,407	33,361	27,630	40,247
Value	thousands	$847	$1,158	$1,346	$1,205	$1,811
Other	short tons	1,584	2,105	2,025	1,739	5,000
Value	thousands	$43	$62	$66	$60	$175
Total[3]	short tons	74,878	89,932	86,000	68,184	114,121
Value[3]	thousands	$2,807	$3,453	$3,665	$2,783	$4,511

[1]Includes amorphous silica and Pennsylvania rottenstone.
[2]Partly estimated.
[3]Data may not add to totals shown because of independent rounding.

SPECIAL SILICA STONE PRODUCTS

Special silica stone products produced in 1976 included oil stones from Arkansas, whetstones from Arkansas and Indiana, grindstones from Ohio, grinding pebbles and deburring media from Minnesota and Wisconsin, and tube-mill liners from Minnesota. Output decreased 9%.

Producers of oilstones and whetstones in Garland County, Ark., were John O. Glassford; Hiram A. Smith, Inc.; Arkansas Abrasives, Inc.; and Norton Pike Division of Norton Co. Whetstones were produced by Milroy and Smith in Hot Springs County, Ark., and by K & K Mines, Inc., in Pike County, Ark. Hindostan Whetstone Co. operated a plant in Lawrence County, Ind., to finish stone obtained from a quarry in Orange County, Ind. Cleveland Quarries Co., produced grindstones at its Amherst quarry, Lorain County, Ohio. Jasper Stones Co. produced grinding media, rough and rounded, from its quarry in Rock County, Minn., and Baraboo Quartzite Co., Inc., produced deburring media at its quarry in Sauk County, Wis.

Table 6.—Special silica stone products sold or used in the United States[1]

Year	Quantity (short tons)	Value (thousands)
1972	3,241	$670
1973	3,466	[r]667
1974	3,134	717
1975	2,953	1,061
1976	2,696	1,404

[r]Revised.
[1]Includes grinding pebbles, grindstones, oilstones, tube-mill liners, and whetstones.

NATURAL SILICATE ABRASIVES

Garnet.—Sales of domestic garnet increased 43% in quantity and 62% in value from those of 1975. Three producers were active in 1976—two in Idaho and one in New York. Barton Mines Corp., Warren County, N.Y. sold garnet for use in coated abrasives, glass grinding and polishing, and metal lapping. Emerald Creek Garnet Milling Co. and Idaho Garnet Abrasive Co., both in Benewah County, Idaho, reported their garnet was used in sandblasting, water filtration, as a filler in rubber products, and as an additive in decorations.

Table 7.—Abrasive garnet sold or used by producers in the United States

Year	Quantity (short tons)	Value (thousands)
1972	18,916	$1,957
1973	22,772	2,380
1974	24,684	2,551
1975	17,204	1,690
1976	24,565	[e]2,740

[e]Estimate.

NATURAL ALUMINA ABRASIVES

Corundum.—No domestic corundum was produced in 1976. Requirements for domestic consumption were met by imports, mainly from the Republic of South Africa. Total imports were 3,074 tons at a declared value of $229,987.

Prices quoted in Engineering and Mining Journal, December 1976, for crystal corundum, per short ton of crude, c.i.f., U.S. ports, were $150 to $160.

Emery.—Two producers of emery were active in 1976: De Luca Emery Mine, Inc., and Emeri Crete, Inc., both near Peekskill in Westchester County, N.Y. Domestic emery was used mostly in aggregates as a nonslip additive for floors, pavements, and stair treads. The minor use for domestic emery was in abrasive materials for coated abrasives and tumbling or deburring media.

World production data for emery are principally for Greece and Turkey. In 1975, production of emery in Greece was estimated to be 7,700 short tons. Production of emery in Turkey in 1975 was reported as 70,670 short tons. No value was reported on either Greek or Turkish production.

Prices quoted in Industrial Minerals, No. 99, December 1976, for emery, per metric ton, c.i.f., main European port were $127 to $136 for coarse grain and $136 to $153 for medium and fine grain.

Table 8.—Natural corundum: World production, by country

(Short tons)

Country[1]	1974	1975	1976[p]
India	360	337	582
South Africa, Republic of	278	266	157
U.S.S.R.[e]	7,700	8,300	8,300
Uruguay	366	460	420
Total	8,704	9,363	9,459

[e]Estimate. [p]Preliminary.

[1]In addition to the countries listed, Southern Rhodesia presumably continued to produce natural corundum at a significant level (several thousand tons annually), and both Argentina and Kenya may have produced minor quantities of this commodity, but output is not reported and available information is inadequate for the formulation of reliable estimates of output levels.

INDUSTRIAL DIAMOND

Domestic production of synthetic industrial diamond in 1976 was estimated to be 25.3 million carats, an increase of 6.3 million carats from above of 1975. Secondary production, comprising salvage from used diamond tools and from wet and dry diamond-containing wastes, was estimated to be 2.7 million carats from a consumption canvass by the Department of Commerce.

The Government stockpile inventory as of December 31, 1976, was 31.0 million carats of crushing bort and 20.0 million carats of stones. The goal for crushing bort was 15.0 million carats and 5.6 million for stones. Available for disposal from prior enabling legislation were 9.9 million carats of bort.

Diamonds in a serpentinized garnet peridotite nodule from diotreme-pipe in southern Wyoming were the first known North American occurrence in an upper-mantle peridotite xenolith from a kimberlite intrusion, as well as the second authenticated North American occurrence of diamond from kimberlite pipes.[2]

Exports and reexports of industrial diamond dust and powder, which included synthetics, were 14.5 million carats valued at $36.2 million. Crushing bort, except dust and powder, exported was 433,000 carats valued at $2.3 million. Exports and reexports of stones were 3.1 million carats valued at $29.7 million. The total of exports and reexports of dust and powder, bort, and stones was 18.0 million carats valued at $68.2 million.

[2]McCallum, M. E. Diamonds in an Upper Mantle Peridotite Nodule From Kimberlite in Southern Wyoming. Science, v. 192, No. 4236, pp. 253-256.

Table 9.—U.S. imports for consumption of industrial diamond (excluding diamond dies)

(Thousand carats and thousand dollars)

Year	Quantity	Value
1974	18,417	62,920
1975	14,291	53,383
1976	17,047	61,102

Table 10.—U. S. imports for consumption of industrial diamond, by country

(Thousand carats and thousand dollars)

Country	Crushing bort (including all types of bort suitable for crushing)				Other industrial diamond (including glazers' and engravers' diamond, unset)				Miners' diamond				Powder and dust			
	1975		1976		1975		1976		1975		1976		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Australia	--	--	--	--	(1)	8	(1)	2	--	--	--	--	--	--	1	1
Belgium-Luxembourg	--	--	--	--	370	1,477	591	2,329	6	54	(1)	1	191	248	818	1,218
Canada	3	5	2	15	65	364	67	564	2	17	9	53	63	60	28	44
Central African Republic	--	--	--	--	4	14	(1)	1	--	--	--	--	--	--	--	--
Congo	--	--	--	--	66	301	15	54	--	--	--	--	(1)	(1)	--	--
Cyprus	--	--	--	--	--	--	15	35	--	--	--	--	--	--	--	--
Finland	--	--	--	--	--	--	88	121	--	--	--	--	--	--	--	--
France	--	--	--	--	9	299	--	--	(1)	8	2	23	11	25	3	8
Germany, West	1	3	--	--	5	55	3	43	(1)	(1)	1	2	111	159	11	28
Ghana	--	--	--	--	11	112	9	125	1	15	2	31	--	--	19	27
Gibraltar	--	--	--	--	--	--	--	--	--	--	--	--	25	32	--	--
Greece	--	--	--	--	--	--	--	--	--	--	--	--	--	--	71	94
Hong Kong	--	--	--	--	--	--	3	46	6	35	--	--	--	--	7	12
Ireland	14	36	--	--	12	63	101	471	1	3	109	159	4,436	10,328	5,705	13,250
Israel	(1)	2	--	--	11	167	13	359	(1)	12	--	--	2	3	2	4
Japan	--	--	--	--	28	476	27	563	116	216	130	197	654	1,209	659	1,088
Liberia	--	--	--	--	--	--	13	42	--	--	2	26	--	--	--	--
Mexico	--	--	--	--	--	--	(1)	1	--	--	--	--	15	25	23	41
Netherlands	108	208	53	131	89	852	163	1,425	--	--	18	32	53	173	38	84
Sierra Leone	--	--	--	--	10	198	(1)	1	3	15	--	--	--	--	--	--
South Africa, Republic of	157	413	113	210	2,648	18,404	2,901	19,741	742	4,262	94	549	1,408	3,562	2,324	5,471
Switzerland	--	--	--	--	(1)	16	16	1,018	--	--	--	--	78	92	127	191
U.S.S.R	(1)	(1)	--	--	60	78	--	--	--	--	--	--	671	910	479	610
United Kingdom	(1)	1	14	35	374	2,491	405	3,222	28	162	37	208	738	1,085	904	1,498
Venezuela	--	--	--	--	16	174	25	716	26	600	91	596	--	--	--	--
Western Africa, n.e.c.[2]	--	--	--	--	305	1,961	9	117	--	--	--	--	220	243	(1)	(1)
Zaire	--	--	4	11	5	55	4	17	226	1,325	624	3,695	45	123	39	94
Other	--	--	--	--	8	71	16	331	9	49	(1)	19	25	29	(1)	2
Total	283	668	186	402	4,096	27,636	4,484	31,344	1,166	6,773	1,119	5,591	8,746	18,306	11,258	23,765

[r]Revised.
[1]Less than 1/2 unit.
[2]Prior to 1975, formerly Western Portugeuse Africa.

WORLD REVIEW

Australia.—An exploration consortium confirmed that diamond was found in the Kimberly Region of Western Australia. Systematic sampling yielded some 160 stones of approximately 7 carats total weight. There has been no announcement as to whether kimberlite pipes have been found.[3]

Botswana.—At the Orapa mine 3,428,985 tons were processed in 1976, compared with 3,048,020 tons in 1975. Diamond production was 2,360,945 carats in 1976, compared with 2,397,245 carats in 1975. The Mopipi Dam provided all water requirements for Orapa in 1976. Construction work is in progress at the Orapa mine to increase capacity from 2.3 million carats to 4.5 million carats per year. A new kimberlite pipe was discovered in southern Botswana; accurate assessment of its potential will require a detailed underground sampling program, which will take about 4 years to complete.[4]

Ghana.—Consolidated Diamond Ltd. has estimated remaining diamond deposits along the lower Birim River to yield about 50 million carats. The deposits will be mined at a rate of 2 million carats per year. Ghana has begun to exploit this new deposit because the traditional diamond area at Akwatia in Akyem Abuakwa is expected to be phased out by 1980. Two other small firms, Cayo Ltd. and Dunkwa Goldfields Ltd., are no longer active.[5]

Lesotho.—The Letseng-La-Terai diamond mine is on schedule and was in production in 1976. Overlying soft, weathered kimberlite was mined and stockpiled with the object of exposing harder kimberlite at depth. Mining and recovery operations have been geared to winning larger stones, with primary sorting and washing done when the ore is still at a fairly large size to prevent crushing such stones.[6]

South Africa, Republic of.—Record diamond sales of $1,555 million, 46% higher than in 1975, has caused De Beers Consolidated Mines Ltd. to draw on stockpiles. Sales of industrial diamond, both natural and synthetic, reached a record high in 1976. Total diamond production fell from 10,760,118 carats to 10,523,267 carats. No breakdown was given for sales of either gem stones or industrial diamond. Production is being increased to 1.4 million carats per year at the Namaqualand mine to decrease reliance on the mines in the Territory of South-West Africa.[7]

TECHNOLOGY

Synthesis of cubic boron nitride using high-pressure, high-temperature technology was announced by De Beers Industrial Diamond Div., Ltd. The grit obtained by the De Beers process is from 80 to 230 U.S. mesh in size and comprises clear, amber-colored crystals of high purity. The shapes are described as irregular with smooth crystal faces or irregular fracture surfaces.[8]

Megadiamond Corp., Provo, Utah, produced a fiber spinnert for the synthetic fiber industry from sintered polycrystalline diamond material.[9]

National Research Co. added the processing of copper- and nickel-coated natural and synthetic diamond to its diamond and carbide recovery operations.[10]

De Beers Diamond Research Center in Johannesburg, Republic of South Africa, reported progress on a number of projects, among which were the following:[11]

A new diamond-crushing system was installed for processing smaller diamond grit sizes. Results indicate a high yield of blocky grit particles with sharp well-defined edges that are suited for stone-sawing and glass-grinding operations.

Carbide Diamond Abrasive (CDA) was synthesized especially for use in the grinding of tungsten carbide. The particles have a polycrystalline mosaic structure and break away in very small chips. New sharp cutting edges are constantly generated.

Precise monitoring of the absorbed radiation dose is essential during treatment of cancer by radiotherapy. Diamond can contribute toward accurate medical dosimetry and successful radiotherapy. Properties that make diamond attractive for this use are low conductivity, low trapping rate, and high carrier mobility.[12]

Successful tests demonstrate the effectiveness of X-ray topographic maps. In-

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[3]U.S. Embassy, Canberra, Australia. State Department Airgram A-110, Oct. 15, 1976, p. 11.

[4]De Beers Consolidated Mines Ltd. 1976 Annual Report. 59 pp.

[5]Mining Engineering. Industry Newswatch. V. 29, No. 2, February 1977, p. 30.

[6]Engineering & Mining Journal. News Briefs. V. 177, No. 8, p. 137.

[7]Work cited in footnote 4.

[8]Iron Age. Now There Are Two CBN Abrasives. V. 217, No. 5, Feb. 2, 1976, pp. 41-43.

[9]Chemical and Engineering News. Diamond Orifices May Cut Fiber Costs. V. 54, No. 29, July 12, 1976, p. 20.

[10]Born, W. E. Your Diamond and Carbide Waste Can Be Worth Thousands. Machine and Tool Blue Book, v. 71, No. 7, July 1976, pp. 77-83.

[11]Work cited in footnote 4.

[12]Bampton, F. K. A Medical Application for Radiosensitive Diamonds. Industrial Diamond Review, February 1976, pp. 55-59.

Table 11.—Diamond (natural): World production, by country[1]

(Thousand carats)

Country	1974 Gem	1974 Industrial	1974 Total	1975 Gem	1975 Industrial	1975 Total	1976^p Gem	1976^p Industrial	1976^p Total
Africa:									
Angola	1,470	490	1,960	345	115	^e460	495	165	^e660
Botswana	408	2,310	2,718	360	2,037	2,397	354	2,007	2,361
Central African Republic	220	118	338	220	119	339	221	119	^e340
Ghana	257	2,315	2,572	233	2,095	2,328	228	2,055	2,283
Guinea^e	25	55	80	25	55	80	25	55	80
Ivory Coast	112	167	279	84	125	209	22	38	60
Lesotho[2]	2	9	11	1	2	3	1	2	^e3
Liberia[3]	377	259	636	[4]241	[4]165	[4]406	250	150	^e400
Sierra Leone^e	670	1,000	1,670	600	900	1,500	600	900	1,500
South Africa, Republic of:									
Premier mine	605	1,817	2,422	509	1,527	2,036	458	1,375	1,833
Other DeBeers properties[5]	2,397	1,961	4,358	2,518	2,061	4,579	2,549	2,086	4,635
Other	438	292	730	408	272	680	332	222	554
Total	3,440	4,070	7,510	3,435	3,860	7,295	3,339	3,683	7,022
South-West Africa, Territory of	1,491	79	1,570	1,660	87	1,747	1,609	85	1,694
Tanzania	249	249	498	224	224	448	225	225	^e450
Zaire	^r620	^r12,991	13,611	395	12,415	12,810	591	11,230	11,821
Other areas:									
Brazil	127	127	254	135	135	^e270	135	135	^e270
Guyana	12	18	30	8	13	21	6	8	14
India	18	3	21	17	3	20	17	3	20
Indonesia^e	12	3	15	12	3	15	12	3	15
U.S.S.R	1,900	7,600	9,500	1,950	7,750	9,700	2,000	7,900	9,900
Venezuela	279	970	1,249	239	821	1,060	190	643	833
World total	^r11,689	^r32,833	44,522	10,184	30,924	41,108	10,320	29,406	39,726

^eEstimate. ^pPreliminary. ^rRevised.

[1]Total (gem plus industrial) diamond output for each country is actually reported except where indicated to be an estimate by footnote. In contrast, the detailed separate reporting of gem diamond and industrial diamond represents Bureau of Mines estimates in the case of every country except Lesotho (1974-75), Liberia (1974), Venezuela (all years), and Zaire (1974-75) where sources give both total output and detail. The estimated distribution of total output between gem and industrial diamond is conjectural in the case of a number of countries, based on unofficial information of varying reliability.

[2]Exports of diamond originating in Lesotho; excludes stone imported for cutting and subsequently reexported.

[3]Exports.

[4]Partial figure; January 1 through December 15 only.

[5]All company output from the Republic of South Africa except for that credited to the Premier mine; also excludes company output from the Territory of South-West Africa and Botswana.

ternal crystal lattice defects act as fingerprints that unambiguously identify a given cut gem with its parent rough stone or identify the gem even though it may have been recut.[13]

Boron is the dopant responsible for the acceptor center in semiconducting diamond. Other potential donors and acceptors are discussed. At normal temperatures, conduction occurs in the valence bond. At low temperatures, and particularly in heavily boron-doped synthetic diamond, an impurity bond is formed, and conduction takes place through variable range hopping. Limited success has been achieved by ion implantation of boron.[14]

Abstracts relative to properties of diamond-hard materials, machines, and patents were published monthly in the Industrial Diamond Review. Each issue, January to December 1976, contained from 14 to 18 pages of abstracts and patent information.

ARTIFICIAL ABRASIVES

Five firms produced crude fused aluminum oxide in the United States and Canada in 1976. Operators of plants in both countries were The Carborundum Co., Norton Co., and General Abrasive Co., Div. of U.S. Industries. The Exolon Co. and Simonds Canada Abrasive Co., Ltd., operated plants in Canada. The production of white, high-purity material was 30,279 tons, and pro-

[13]Lang, A. R., and G. S. Woods. Fingerprinting Diamonds by X-Ray Topography. Industrial Diamond Review, March 1976, pp. 96-103.

[14]Bourgoin, J. D., and J. Walker. Electrical Conduction in Diamond. Industrial Diamond Review, October 1977, pp. 362-367.

duction of regular grade was 160,512 tons. Of the combined output of white and regular, 12% was used for nonabrasive applications, principally in the manufacture of refractories. The production was 62% of the rated capacity of the furnaces assigned to fused aluminum oxide production. Yearend stocks were reported as 11,935 tons.

One firm, General Abrasive Co., Div. of U.S. Industries, produced fused-alumina zirconia abrasive in the United States and in Canada; and three firms, The Carborundum Co., Norton Co., and Exolon Co., operated plants in Canada. All production was reportedly used for abrasive applications. The output was 58% of the capacity of the furnaces assigned to the production of fused-alumina zirconia. Yearend stocks were reported as 1,259 tons.

Six firms in the United States and in Canada produced silicon carbide in 1976. The Carborundum Co. operated plants in both countries. Electro-Refractories & Abrasives Canada, Ltd., Exolon Co., Norton Co., and General Abrasive Co., Div. of U.S. Industries, operated in Canada. These five companies produced crude for abrasive uses and for refractory and other nonabrasive uses. Satellite Alloy Corp. operated in the United States and produced crude for nonabrasive applications. Production by the six firms was 81% of capacity, and 37% was reportedly used for abrasive applications. Nonabrasive use was 63% of the output and was mostly for refractory and metallurgical applications. Yearend stocks were reported as 11,326 tons.

In the Stockpile Report to the Congress by the General Services Administration, the inventory of crude fused aluminum oxide in calendar 1976 was reduced to 249,009 tons, with 77,229 tons uncommitted excess; the stock of aluminum oxide grain was unchanged at 50,905 tons, with the goal increased to 75,000 tons; and the stock of silicon carbide crude was 80,619 tons, with the goal increased to 306,628 tons.

Metallic abrasives were produced by 13 firms in the United States in 1976. Steel shot and grit comprised 77% of the total quantity sold or used; chilled iron shot and grit, 14%; and annealed iron shot and grit, 9%. The amounts from Ohio were 25% of the total sold or used, the highest of the producing States. Michigan, Indiana, Pennsylvania, Alabama, New York, and Connecticut followed in quantity sold or used. Three companies recycled material: Copperweld Steel Co., Glassport, Pa.; Industeel Corp., Pittsburgh, Pa; and Kohler Co., Sheboygan, Wis.

TECHNOLOGY

Ceramics are prone to surface damage caused by grinding, cutting, thermal shocking, impacting, and even handling. The resulting flaws cause a decrease in the actual strength of ceramics. Thermally shocked alumina regains its strength when annealed. Cracks appear to heal via the disappearance of void space between the grains. The major event during healing involves pore evolution.[15]

Submicrometer-sized high-purity powders were offered by Aremco Products, Inc., Ossining, N.Y. These powders include aluminum, aluminum carbide, barium titanate, boron carbide, cobalt oxide, hafnium boride, manganese, silicon, silicon nitride, tantalum oxide, titanium nitride, tungsten diboride, vanadium diboride, and zirconium carbide.[16]

Coated-abrasives manufacturers introduced specialized products characterized by high-tensile, low-stretch, tear-resistant polyester cloth backing, an improved phenolic resin-modified bond system, and sharp shape classified aluminum oxide grain. The new abrasives are beginning to make significant inroads into paperbacked products for metalworking.[17]

Zirconia alumina abrasives have had great impact on metal and woodworking industries. Used in grinding wheels and coated abrasives they have provided 50% to 250% increases in productivity.[18]

Escalating production costs, new technologies, tightening air-pollution regulations, and changing market conditions are forcing changes in the U. S. abrasives industry. Abrasive makers are moving away from direct competition in several market areas; each firm is concentrating on those segments of the market in which it holds strong technological or marketing advantages.[19]

The Carborundum Co. completed a new electric furnace for the production of fused

[15]Gupta, T. K. Crack Healing and Strengthening of Thermally Shocked Alumina. J. Am. Cer. Soc., v. 59, No. 5-6, May-June 1976, pp. 259-262.

[16]American Metal Market and Metalworking News. Fine High Purity Powders Offered. V. 83, No. 32, Feb. 16, 1976, p. 29.

[17]Larsen, R. Polyester-Backed Abrasives Gain Ground on Paper-Backed Products. Am. Metal Market and Metalworking News, v. 83, No. 51, Mar. 15, 1976, p. 6.

[18]Foundry Management & Technology. New Light on Zirconia Alumina Abrasives. V. 104, No. 5, May 1976, pp. 69-72.

[19]Larsen, R. Change Invades Abrasive Field. Am. Metal Market and Metalworking News, v. 83, No. 126, June 28, 1976, pp. 1, 15.

aluminum oxide. The furnace has a capacity of 50,000 tons per year and uses less electric power per ton of output. Ferrosilicon is bottom-tapped from the furnace.[20]

Advanced ceramics are being used in industrial applications. Manufacturers of industrial and aircraft gas turbine engines are giving serious consideration to commercial applications as design factors are more well known. Advanced ceramics have high strength at temperatures of 2,500°F and higher. They are extremely resistant to oxidation and corrosion at high temperatures. They have very low coefficients of thermal expansion. These materials resist mechanical and thermal shock almost as well as most superalloys and are 60% lighter. Special cooling is not required to maintain high-temperature strength.[21] [22]

Airless blast cleaning gives processors low-cost, environmentally clean options for a systems approach to surface preparation. White or near-white clean metal surfaces are being increasingly specified by designers, engineers, and architects. A single blast wheel powered by 25 to 30 horsepower will clean 15 square feet or more per minute.[23]

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[20]Larsen, R. New Carborundum Furnace To Hike Aluminum Oxide Output, Cut Costs. Am. Metal Market and Metalworking News, v. 83, No. 126, June 28, 1976, p. 11.

[21]Iron Age. Advanced Ceramics Compete for Industrial Jobs. V. 217, No. 18, May 3, 1976, pp. 51, 53.

[22]Materials Engineering. Silicon Carbide Powder Permits Complex Shapes. Nonmetallic News. V. 84, No. 2, August 1976, p. 19.

[23]Iron Age. Technology, Shot Blast Cleaning Heads in New Directions. V. 218, No. 7, Aug. 16, 1976, pp. 27-31.

Table 12.—Producers of metallic abrasives in 1976

Company	Location	Product shot and/or grit
Abbott Ball Co	West Hartford, Conn	Steel.
Abrasive Materials, Inc	Hillsdale, Mich	Steel and stainless steel cut wire.
Abrasive Metals Co	Pittsburgh, Pa	Chilled iron and annealed iron.
The Carborundum Co., Pangborn Div	Butler, Pa	Steel.
Cleveland Metal Abrasive Co	Birmingham, Ala	Do.
Do	Cleveland, Ohio	Do.
Do	Howell, Mich	Chilled iron.
Do	Springville, N.Y	Do.
Do	Toledo, Ohio	Steel.
Durasteel Co	Mt. Pleasant, Pa	Do.
Ervin Industries, Inc	Adrian, Mich	Chilled iron and steel.
Globe Steel Abrasive Co	Mansfield, Ohio	Chilled and annealed iron.
Metal Blast, Inc	Cleveland, Ohio	Do.
National Metal Abrasive Co	do	Steel.
Pellets, Inc	Tonowanda, N.Y	Steel and stainless steel cut wire.
Steel Abrasives, Inc	Hamilton, Ohio	Chilled and annealed iron.
Wheelabrator-Frye Inc	Mishakawa, Ind	Steel.

Table 13.—Crude artificial abrasives produced in the United States and Canada

(Thousand short tons and thousand dollars)

Kind	1972	1973	1974	1975	1976
Silicon carbide[1]	166	162	163	134	159
Value	$24,690	$25,471	$33,872	$31,842	$45,953
Aluminum oxide (abrasive grade)[1]	184	196	241	141	191
Value	$28,590	$27,339	$40,906	$28,368	$43,356
Aluminum zirconium oxide	--	22	25	17	20
Value	--	$6,223	$9,839	$8,506	$11,383
Metallic abrasives[2]	235	266	301	236	250
Value	$39,678	$49,775	$91,061	$72,864	$75,372
Total	585	646	730	528	620
Value	$92,958	$108,808	$175,678	$141,580	$176,064

[1]Figures include material used for refractories and other nonabrasive purposes.
[2]Shipments for U.S. plants only.

Table 14.—Production, shipments, and annual capacities of metallic abrasives in the United States, by product

Year and product	Manufactured		Sold or used		Annual capacity[1] (short tons)
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	
1975:					
Chilled iron shot and grit	28,352	$5,539	34,904	$8,428	124,593
Annealed iron shot and grit	23,967	5,086	25,010	7,004	49,640
Steel shot and grit	178,211	46,338	175,620	56,837	265,650
Other[2]	543	455	583	595	2,400
Total	231,073	57,418	236,117	72,864	442,283
1976:					
Chilled iron shot and grit	26,556	5,433	34,025	8,015	124,550
Annealed iron shot and grit	21,109	4,598	21,688	5,699	52,540
Steel shot and grit	188,717	48,125	193,300	61,054	320,670
Other[2]	798	451	851	604	2,140
Total	237,180	58,607	249,864	75,372	499,900

[1]The total quantity of the various types of metallic abrasives that a plant could have produced during the year, working three 8-hour shifts per day, 7 days per week, allowing for usual interruptions, and assuming adequate fuel, labor, and transportation.
[2]Includes cut wire shot.

Aluminum

By John W. Stamper[1] and Christine M. Monroe[2]

World primary aluminum production increased about 3% during 1976 as producers restarted potlines idled in 1975. Stocks of primary aluminum held by members of the International Primary Aluminum Institute (IPAI), which represents the bulk of inventories held outside the centrally controlled economies, decreased about 25% during 1976.

U.S. aluminum demand, as measured by net shipments of aluminum ingot and mill products to domestic industry, increased 31% compared with the 1975 level. Total metal inventories held by the domestic industry at yearend 1976 were 6% lower than at the beginning of the year.

Primary aluminum production capacity increased during the year in 16 countries, including Brazil, Ghana, India, Japan, New Zealand, and Taiwan. Additional production capacity was under consideration in Brazil, Indonesia, Mexico, Trinidad, and the U.S.S.R.

Table 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Primary production	4,122	4,529	4,903	3,879	4,251
Value	$2,084,946	$2,206,440	$3,005,640	$2,976,427	$3,785,753
Price: Ingot, average cents per pound	26.3	25.3	34.1	39.8	44.6
Secondary recovery	946	1,040	993	980	1,155
Exports (crude and semicrude)	329	561	524	r440	484
Imports for consumption (crude and semicrude)	794	614	629	550	749
Aluminum industry shipments[1]	5,744	6,873	6,394	4,555	5,953
Consumption, apparent[2]	4,926	5,825	5,428	3,904	5,118
World: Production	12,133	13,364	r14,516	r13,352	13,774

rRevised.
[1]To domestic industry.
[2]Not comparable to previous years. See table 6 for derivation.

Legislation and Government Programs.—The shipment of 9,181 tons of primary aluminum from government inventories during 1976 under the aluminum disposal program that became effective November 23, 1965, brought the total shipped under the program to almost 1.9 million tons. From December 1, 1965 to December 31, 1976, shipments of primary aluminum by the General Services Administration were as follows, in short tons:

1965	9,374
1966	325,925
1967	61,599
1968	56,554
1969	139,635
1970	24,261
1971	21
1972	6,125
1973	730,249
1974	510,741
1975	2,486
1976	9,181
Total	1,876,151

[1]Physical scientist, Division of Nonferrous Metals.
[2]Mineral specialist, Division of Nonferrous Metals.

DOMESTIC PRODUCTION

Primary.—Primary aluminum production increased about 10% during 1976 to 4,251,395 tons, compared with 3,879,146 tons in 1975. Primary producers restarted potlines idled in 1975 due to decreased demand and by yearend 1976 smelters were operating at 90% of rated capacity compared with 74% at yearend 1975.

Domestic primary aluminum production capacity increased slightly from that of 1975 to 5,193,000 tons per year. The Aluminum Company of America (Alcoa) began production at its 15,000-ton-per-year Palestine, Tex., facility. The smelter used an experimental process based on the electrolysis of aluminum chloride and reportedly used 4.2 kilowatt-hours per pound of aluminum produced, compared with 6.0-7.0 kilowatt-hours per pound of aluminum produced in the most efficient Hall-type cells, and with an industry average of about 8 kilowatt-hours per pound.

Noranda Aluminum, Inc., a subsidiary of Noranda Mines, Ltd., completed the expansion of its New Madrid, Mo., smelter to 140,000 tons per year.

Alcoa announced that it was studying the feasibility of an additional potline at its Alcoa, Tenn., smelter. The issuance of revenue bonds to finance pollution control equipment for the expansion was authorized by the Blount County Industrial Development Board.

Alcoa agreed to supply Texas Power & Light Co. with lignite for a generating plant that the power company will build to supply power to Alcoa's 285,000-ton-per-year smelter at Rockdale, Tex.

Anaconda Aluminum Co. was licensed to use the Alcoa dry-scrubbing process for control of fluoride emissions at Anaconda's Columbia Falls, Mont., smelter.

Kaiser Aluminum & Chemical Corp. signed contracts with Devon Corp. and Eason Oil Co. to determine the extent of gas reserves in the vicinity of Kaiser's 163,000-ton-per-year primary smelter at Ravenswood, W.Va. The smelter could be expanded by 50,000 tons per year if long-term power were available.

Martin Marietta Aluminum Inc. began modernization and technological improvement at its Goldendale, Wash., and The Dalles, Oreg., smelters. Emission controls and solid-state electric power rectification equipment were installed to increase operating efficiency of the plants.

The Bonneville Power Administration (BPA) sent notices of insufficiency to its industrial users stating that there would not be enough generating capacity to meet projected demand by the early 1980's. If this occurs electric power from BPA reportedly would not be able to provide sufficient power to aluminum producers after their current contracts expire. The contracts of the six primary aluminum producers in the Pacific Northwest expire between 1984 and 1988.

Secondary.—Recovery of secondary aluminum-base scrap, calculated from reports to the Bureau of Mines, was 1,155,018 tons, 18% higher than the quantity recovered in 1975. Calculated recovery of all metallic constituents from aluminum-base scrap in 1976 increased 18% compared with the 1975 level.

The Bureau estimated that full coverage of the industry would indicate a total scrap consumption of 1,741,000 tons in 1976. On this basis, aluminum recovery would total 1,371,000 tons and total metallic recovery would be 1,471,000 tons.

Hall Aluminum Co. installed a 150,000-pound capacity aluminum refining furnace at its Chicago Heights, Ill. smelter, increasing the facility's aluminum-melting capacity to 40,000 tons per year. Keystone Georgia Metal Co. began production at its Greensboro, Ga., secondary aluminum smelter which was converted from a copper-scrap-processing plant. Texas Reduction Corp. reportedly began production at its new secondary aluminum smelter in Houston, Tex. The $1.7 million plant had a capacity of 22,000 tons per year. Alcan Aluminium Ltd. purchased 50% interest in International Alloys, Inc., which operated a 14,000-ton-per-year secondary smelter in Joliet, Ill. Alcoa began operations at its 4,200-ton-per-year recycling facility for aluminum cans in Houston, Tex. American Can Co. announced that its subsidiary, U.S. Reduction Co., planned to build a $2 million plant in Anniston, Ala., to recover aluminum from scrapped automobiles.

A municipal-waste-processing plant began operations in New Orleans, La. Monthly output of the facility reportedly would be 1,200 tons of steel and glass, 520 tons of copper, 94 tons of aluminum, and other metals such as brass, tin, zinc, and copper. At full capacity the $6.5 million recovery plant was expected to process 650 tons of waste per day at a projected cost of $11 per ton.

Table 2.—Consumption of and recovery from purchased new and old aluminum scrap in 1976[1]

(Short tons)

Class	Consumption	Calculated recovery	
		Aluminum	Metallic
Secondary smelters	758,992	598,765	645,639
Primary producers	365,190	314,248	336,713
Fabricators	121,212	107,506	114,818
Foundries	99,907	86,458	92,607
Chemical producers	120,161	46,139	48,637
Total	1,465,462	1,153,116	1,238,414
Estimated full industry coverage	1,741,000	1,371,000	1,471,000

[1]Excludes recovery from other than aluminum-base scrap.

Table 3.—Aluminum recovered from purchased scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1975	1976	Form of recovery	1975	1976
New scrap:			Unalloyed	4,519	1,685
Aluminum-base	[1]696,698	[2]813,907	Aluminum alloys	914,523	1,080,300
Copper-base	66	83	In brass and bronze	77	77
Zinc-base	119	238	In zinc-base alloys	978	1,308
Magnesium-base	231	140	In magnesium alloys	509	446
			Dissipative forms[3]	59,734	71,202
Total	697,114	814,368	Total	980,340	1,155,018
Old scrap:					
Aluminum-base	[1]282,044	[2]339,209			
Copper-base	45	65			
Zinc-base	859	1,070			
Magnesium-base	278	306			
Total	283,226	340,650			
Grand total	980,340	1,155,018			

[1]Aluminum alloys recovered from aluminum-base scrap in 1975, including all constituents, were 742,993 tons from new scrap and 305,882 tons from old scrap and sweated pig, a total of 1,048,875 tons.
[2]Aluminum alloys recovered from aluminum-base scrap in 1976, including all constituents, were 868,301 tons from new scrap and 370,113 tons from old scrap and sweated pig, a total of 1,238,414 tons.
[3]Includes recovery in deoxidizing ingot assuming 85% aluminum content in such ingot.

Table 4.—Stocks, receipts, and consumption of purchased new and old aluminum scrap and sweated pig in the United States in 1976[1]

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1[r]	Net receipts[2]	Consumption	Stocks Dec. 31
Secondary smelters:				
New scrap:				
Solids and clippings	15,387	229,819	230,629	14,577
Borings and turnings	8,387	134,315	135,504	7,198
Foil	449	871	1,179	141
Dross and skimmings	6,265	130,150	126,467	9,948
Other	663	24,444	24,238	869
Total new scrap	31,151	519,599	518,017	32,733
Old scrap:				
Castings, sheet, and clippings	12,350	119,618	120,783	11,185
Aluminum cans	664	8,017	8,171	510
Other[3]	1,827	32,450	29,915	4,362
Total old scrap	14,841	160,085	158,869	16,057
Sweated pig	20,760	90,885	82,106	29,539
Total all classes	66,752	770,569	758,992	78,329
Primary producers, foundries, fabricators, and chemical plants:				
New scrap:				
Solids and clippings	43,802	351,577	349,911	45,468
Borings and turnings	376	16,218	16,379	215
Foil	510	6,034	5,376	1,168
Dross and skimmings	2,010	103,826	104,408	1,428
Other	814	61,712	60,828	1,698
Total new scrap	47,512	539,367	536,902	49,977
Old scrap:				
Castings, sheet, and clippings	967	35,514	35,099	1,382
Aluminum cans	6,791	98,043	100,635	4,199
Other[3]	633	16,389	16,637	385
Total old scrap	8,391	149,946	152,371	5,966
Sweated pig	1,148	17,278	17,197	1,229
Total all classes	57,051	706,591	706,470	57,172
Total of all scrap consumed:				
New scrap:				
Solids and clippings	59,189	581,396	580,540	60,045
Borings and turnings	8,763	150,533	151,883	7,413
Foil	959	6,905	6,555	1,309
Dross and skimmings	8,275	233,976	230,875	11,376
Other	1,477	86,156	85,066	2,567
Total new scrap	78,663	1,058,966	1,054,919	82,710
Old scrap:				
Castings, sheet, and clippings	13,317	155,132	155,882	12,567
Aluminum-copper radiators	882	19,058	16,059	3,881
Aluminum cans	7,455	106,060	108,806	4,709
Other	1,578	29,781	30,493	866
Total old scrap	23,232	310,031	311,240	22,023
Sweated pig	21,908	108,163	99,303	30,768
Total all classes	123,803	1,477,160	1,465,462	135,501

[r]Revised.
[1]Includes imported scrap. The reporting companies reported that 6.62% of total receipts of aluminum-base scrap, or 97,803 short tons, was received on toll arrangements.
[2]Includes inventory adjustment.
[3]Includes data on aluminum-copper radiators.

Table 5.—Production and shipments of secondary aluminum alloys by independent smelters

(Short tons)[1]

	1975[2]		1976[2]	
	Production	Shipments	Production	Shipments
Die-cast alloys:				
13% Si, 360, etc. (0.6% Cu, maximum)	55,868	49,204	73,323	71,535
380 and variations	282,054	283,568	375,383	372,804
Other	W	W	W	W
Sand and permanent mold:				
95/5 Al-Si, 356, etc. (0.6% Cu, maximum)	19,401	18,387	20,045	20,202
No. 12 and variations	12,408	12,196	8,179	8,219
No. 319 and variations	36,982	36,452	44,053	43,642
F-132 alloy and variations	13,607	13,777	15,163	15,047
Al-Mg alloys	1,595	1,495	1,260	1,154
Al-Zn alloys	9,873	r9,443	14,675	15,022
Al-Si alloys (0.6% to 2.0% Cu)	4,219	4,309	4,272	4,129
Al-Cu alloys (1.5% Si, maximum)	4,667	4,883	3,970	3,830
Al-Si-Cu-Ni alloys	W	W	W	W
Other	3,608	3,601	2,893	2,899
Wrought alloys: Extrusion billets	48,454	49,536	59,254	59,245
Destructive and other uses: Steel deoxidation:				
Grades 1 and 2	17,474	18,767	27,347	26,318
Grades 3 and 4	2,900	3,005	2,139	2,132
Miscellaneous:				
Pure (97.0% Al)	4,517	630	1,685	2,250
Aluminum-base hardeners	2,954	3,021	2,763	2,952
Other[3]	27,038	26,471	20,675	20,213
Total	547,619	538,745	677,079	671,593

r Revised. W Withheld to avoid disclosing individual company confidential data; included in the "Miscellaneous," and "Other" categories.

[1]Gross weight, including copper, silicon, and other alloying elements. Secondary smelters used 16,902 and 20,700 tons of primary aluminum in 1975 and 1976, respectively, in producing secondary aluminum-base alloys.

[2]No allowance was made for consumption or receipts by producing plants.

[3]Includes data withheld.

CONSUMPTION

The Bureau of Mines estimate of apparent aluminum consumption in end products such as automobiles, cans, air-conditioning equipment, and residential siding, as shown in table 6, increased 31% compared with that of 1975.

Domestic consumption as measured by net shipments of aluminum ingot and mill products to domestic industry also was 31% higher than the 1975 level. Shipments to the building and construction industry, the largest user of aluminum, increased 31% from the 1975 level. The containers and packaging industry was the second largest user of aluminum, with shipments totaling 1,285,000 tons, 28% higher than the 1975 level. Transportation applications increased 44% and shipments to electrical markets increased 9% compared with those of 1975.

The average quantity of aluminum used in 1976 model automobiles was about 87 pounds per unit compared with 84.2 pounds per unit in 1975. Estimates indicated that approximately 100 pounds would be required per unit in 1977 models.

Shipments of aluminum sheet to can producers increased during the year and aluminum was reportedly used for about 28% of the metal cans produced in 1976, compared with about 25% of the market in 1975.

Table 6.—Apparent aluminum supply and consumption in the United States

(Thousand short tons)

	1972	1973	1974	1975	1976
Primary production	4,122	4,529	4,903	3,879	4,251
Change in stocks:[1]					
Aluminum industry	+83	+248	-395	-421	+184
Government	+6	+730	+511	+2	+9
Imports	794	614	629	550	749
Secondary recovery:[2]					
New scrap	876	977	978	905	1,062
Old scrap	250	265	304	334	409
Total supply	6,131	7,363	6,930	5,249	6,664
Less total exports	329	561	524	440	484
Apparent aluminum supply available for domestic manufacturing	5,802	6,802	6,406	4,809	6,180
Apparent consumption [3]	4,926	5,825	5,428	3,904	5,118

[1]Positive figure indicates a decrease in stocks, negative figure indicates an increase in stocks.
[2]Metallic recovery from purchased, tolled, or imported new and old aluminum scrap expanded for full industry coverage.
[3]Apparent aluminum supply available for domestic manufacturing less recovery from purchased new scrap (a measure of consumption in manufactured end products).

Table 7.—Distribution of end use shipments of aluminum products

Industry	1975		1976	
	Quantity (thousand short tons)	Percent of total	Quantity (thousand short tons)	Percent of total
Building and construction	r1,124	22.6	1,478	23.2
Transportation	r854	17.2	1,227	19.2
Containers and packaging	1,000	20.2	1,285	20.2
Electrical	608	12.2	664	10.4
Consumer durables	377	7.6	518	8.1
Machinery and equipment	r324	6.6	452	7.1
Other markets	262	5.3	306	4.8
Statistical adjustment	r6	.1	23	.4
Total to domestic users	4,555	91.8	5,953	93.4
Exports	409	8.2	421	6.6
Total	4,964	100.0	6,374	100.0

rRevised.

Source: The Aluminum Association, Inc.

Table 8.—Net shipments of aluminum wrought[1] and cast products by producers

(Short tons)

	1975[r]	1976
Wrought products:		
Sheet, plate, and foil	2,331,986	3,178,127
Rolled and continuous-cast rod and bar; wire	461,768	492,652
Extruded rod, bar, pipe, tube, shapes; drawn and welded tubing and rolled structural shapes	821,481	1,070,683
Powder, flake, and paste	49,464	66,187
Forgings (including impacts)	48,577	50,108
Total	3,713,276	4,857,757
Castings:		
Sand	98,666	109,824
Permanent mold	143,698	188,678
Die	433,144	605,240
Others	12,218	18,848
Total	687,726	922,590
Grand total	4,401,002	5,780,347

[r]Revised.
[1]Net shipments derived by subtracting the sum of producers' domestic receipts of each mill shape from the domestic industry's gross shipment of that shape.

Source: U.S. Department of Commerce.

Table 9.—Distribution of wrought products

(Percent)

	1975	1976
Sheet, plate, and foil:		
Non-heat-treatable	51.5	54.4
Heat-treatable	3.1	3.1
Foil	8.2	7.9
Rolled and continuous-cast rod and bar; wire:		
Rod, bar and wire	3.4	3.7
Cable and insulated wire	9.1	6.4
Extruded products:		
Rod and bar	.9	.7
Pipe and tubing	1.8	2.0
Shapes[1]	17.7	17.4
Tubing:		
Drawn	.9	1.0
Welded, non-heat-treatable[2]	.8	1.0
Powder, flake, and paste	1.3	1.4
Forgings (including impacts)	1.3	1.0
Total	100.0	100.0

[1]Includes a small amount of rolled structural shapes.
[2]Includes a small amount of heat-treatable welded tube.

Source: U.S. Department of Commerce.

STOCKS

Metal inventories held at reduction and other processing plants as reported by the U.S. Department of Commerce, Bureau of Domestic Commerce (BDC), decreased 6% from 2,999,354 tons (revised) at yearend 1975 to 2,815,324 tons at yearend 1976.

PRICES

The price of 99.5% pure aluminum ingot as quoted by the American Metal Market increased from 41.0 cents per pound at the beginning of 1976 to 44.0 cents per pound on June 1. The price increased an additional 4.0 cents per pound to 48.0 cents per pound on August 13, and remained at that level through yearend.

Prices quoted by the American Metal Market for smelters' secondary aluminum alloys increased from a range of 40.5 to 50.0 cents per pound at the beginning of 1976 to 51.0 to 59.0 cents per pound at yearend.

Prices quoted by the American Metal Market for smelters' scrap aluminum increased from a range of 12.0 to 20.0 cents per pound on January 2 to a range of 22.0 to 30.0 cents per pound on December 30.

FOREIGN TRADE

Exports of crude and semicrude aluminum metal including scrap increased 10% compared with the 1975 level. Exports of aluminum ingot decreased during the year but were offset by a marked increase in exports of scrap. The People's Republic of China received 27%, or 41,170 short tons, of aluminum ingot. Other major recipients of ingot included Japan, Canada, Mexico, and Taiwan. Japan received 60% of the scrap exports during the year.

U.S. imports for consumption of crude and semicrude aluminum including scrap increased 36% to 748,624 short tons compared with 550,279 tons in 1975. Canada supplied 66% of crude metal and alloys and Ghana supplied 16%. Imports of scrap increased sharply during the year; the major sources of scrap were Canada (47%) and the U.S.S.R. (38%).

Table 10.—U.S. exports of aluminum, by class

Class	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Crude and semicrude:				
Ingots, slabs, crude	185,850	$134,064	152,366	$118,644
Scrap	[r]66,937	[r]29,169	108,958	63,245
Plates, sheets, bars, etc	171,008	228,684	203,843	261,759
Castings and forgings	5,008	18,813	5,611	21,232
Semifabricated forms, n.e.c	11,013	25,593	12,937	31,016
Total	[r]439,816	[r]436,323	483,715	495,896
Manufactures:				
Foil and leaf	11,604	24,185	14,785	31,921
Powders and pastes	3,460	5,434	8,440	11,445
Wire and cable	24,416	35,329	26,419	32,576
Total	39,480	64,948	49,644	75,942
Grand Total	[r]479,296	[r]501,271	533,359	571,838

[r]Revised.

... ss and country

Country	1975						1976					
	Ingots, slabs, crude		Plates, sheets, bars, etc.[1]		Scrap		Ingots, slabs, crude		Plates, sheets, bars, etc.[1]		Scrap	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	6,298	$5,060	702	$1,156	--	--	4,636	$3,713	492	$2,008	--	--
Australia	109	100	882	2,217	--	--	35	82	1,372	2,429	--	--
Belgium-Luxembourg	40	18	507	1,303	2,164	$1,028	280	236	401	993	1,612	$651
Brazil	3,469	2,838	4,369	7,112	2,451	952	2,215	2,144	3,772	6,547	3,390	1,856
Canada	17,901	12,591	65,024	83,861	8,413	3,064	19,864	15,254	102,150	127,611	9,750	4,524
Chile	147	141	165	257	--	--	1,283	1,260	135	567	13	16
China, People's Republic of	68,906	46,292	279	528	--	--	41,170	25,641	255	811	--	--
Colombia	641	574	55	115	3	3	215	247	516	795	--	--
Denmark	12	25	4,286	5,378	--	--	49	121	4,857	6,527	20	6
El Salvador	726	650	380	492	--	--	1,921	1,836	582	649	--	--
France	6,711	5,026	1,598	2,870	498	320	9,536	7,701	4,577	8,111	56	29
Germany, West	830	682	7,841	12,072	15,436	6,269	909	898	9,021	13,987	11,964	5,650
Ghana	44	36	302	417	r1,190	r84	24	44	187	320	--	--
Guinea	--	--	1,505	1,797	--	--	--	--	2,000	2,609	--	--
Hong Kong	74	99	201	392	--	--	343	316	326	621	--	--
India	1,876	1,269	18	80	--	--	4	8	6	61	--	--
Iran	1,102	889	259	779	--	--	20	12	776	1,487	--	--
Israel	434	707	2,672	6,356	8	19	156	205	3,003	5,752	--	--
Italy	412	564	3,700	10,308	2,173	930	237	524	4,013	8,550	3,816	1,789
Japan	46,364	31,734	10,441	17,941	22,558	11,368	22,024	17,481	4,684	9,479	65,664	42,399
Korea, Republic of	687	490	1,486	3,391	716	305	1,262	1,188	796	1,138	1,750	945
Mexico	8,272	6,570	22,254	22,855	197	25	17,813	14,861	27,583	32,038	348	86
Netherlands	1,319	1,043	7,149	11,275	2,400	999	73	169	4,188	7,007	316	106
New Zealand	13	12	541	966	--	--	6	19	190	429	--	--
Nigeria	427	755	134	356	--	--	--	--	36	197	--	--
Norway	46	52	11,027	15,699	3	2	16	31	1,504	1,243	--	--
Pakistan	87	62	114	51	2,124	1,377	--	--	46	88	3,596	2,684
Panama	788	574	80	160	--	--	893	765	99	162	--	--
Peru	135	134	22	98	541	338	77	69	19	81	510	390
Philippines	6,904	5,435	152	462	47	43	6,244	5,544	204	570	52	36
Portugal	4	2	346	536	4	1	6	3	90	182	--	--
Saudi Arabia	9	30	828	1,765	--	--	3	2	1,122	2,452	--	--
Singapore	10	11	636	1,022	--	--	166	170	361	699	--	--
South Africa, Republic of	5	16	4,909	6,950	57	32	43	35	3,871	5,733	58	28
Spain	100	48	1,103	1,567	1,810	990	18	38	949	1,700	1,452	500
Sweden	5	10	567	1,306	101	47	13	19	577	1,292	42	26
Switzerland	14	7	144	717	(2)	25	1,680	1,466	74	323	--	--
Taiwan	5,647	4,434	899	2,090	3,379	572	13,354	10,630	947	1,700	3,485	895
Thailand	2,807	2,060	228	487	--	--	473	436	120	286	60	20
United Kingdom	946	1,225	18,191	27,404	305	174	915	1,004	26,898	39,753	384	207
Venezuela	50	184	6,128	7,717	--	--	2,321	2,148	3,955	6,152	1	1
Other	1,479	1,615	4,905	10,785	359	202	2,069	2,324	5,637	10,868	619	401
Total	185,850	134,064	187,029	273,090	r66,937	r29,169	152,366	118,644	222,391	314,007	108,958	63,245

r Revised.
[1] Includes plates, sheets, bars, extrusions, forgings, and unclassified semifabricated forms.
[2] Less than 1/2 unit.

Table 12.—U.S. imports for consumption of aluminum, by class

Class	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	434,119	$316,873	575,350	$439,570
Circles and disks	5,246	6,018	8,475	10,166
Plates,sheets, etc., n.e.c	48,763	48,656	67,042	69,884
Rods and bars	6,903	8,474	11,563	14,563
Pipes, tubes, etc	442	1,931	480	1,699
Scrap	54,806	27,586	85,714	46,166
Total	550,279	409,538	748,624	582,048
Manufactures:				
Foil	2,231	7,715	4,924	14,395
Leaf	(1)	79	(1)	114
Flakes and powders	318	364	285	501
Wire	752	882	928	1,180
Total	3,301	9,040	6,137	16,190
Grand total	553,580	418,578	754,761	598,238

[1]1975—Aluminum leaf not over 30.25 square inches in area, 582,500 leaves, and aluminum leaf over 30.25 square inches in area, 87,653,153 square inches; 1976—aluminum leaf not over 30.25 square inches in area, 1,401,194 leaves, and aluminum leaf over 30.25 square inches in area, 42,803,390 square inches.

Table13.—U.S. imports for consumption of aluminum, by class and country

Country	1975						1976					
	Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap		Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	19	$20	1,254	$1,328	--	--	--	--	2,350	$2,759	--	--
Bahrain	--	--	--	--	--	--	5,318	$3,946	--	--	--	--
Belgium-Luxembourg	214	150	21,950	21,639	--	--	953	658	25,055	26,140	82	$50
Canada	338,468	244,574	3,427	5,347	32,239	$17,917	380,995	292,835	3,607	5,843	39,896	22,269
Finland	--	--	1,076	350	--	--	563	358	--	--	--	--
France	4,815	3,111	5,081	6,977	--	--	6,620	5,154	9,036	9,878	901	585
Germany, West	2,488	1,904	836	1,237	6,673	2,966	413	306	1,272	1,844	2,850	1,499
Ghana	62,389	47,879	--	--	--	--	89,806	69,691	(2)	(2)	--	--
Hong Kong	--	--	689	715	18	12	--	--	1,039	1,108	--	--
India	--	--	2	7	--	--	2,049	1,300	26	28	(2)	1
Italy	--	--	1,647	1,714	15	7	--	--	3,653	3,880	60	48
Jamaica	--	--	--	--	604	289	--	--	--	--	601	369
Japan	842	912	15,104	15,230	249	179	13,463	9,720	16,321	17,703	49	2
Mexico	136	49	7	13	1,742	474	312	142	96	221	1,322	494
Netherlands	10	8	107	106	--	--	19	15	1,432	2,648	--	--
Norway	3,761	3,734	2,645	2,293	--	--	15,503	13,000	4,800	4,224	377	305
Poland	--	--	--	--	--	--	--	--	--	--	1,542	860
Romania	--	--	--	--	--	--	797	484	964	896	--	--
South Africa, Republic of	--	--	--	--	--	--	3,353	2,166	--	--	26	14
Spain	134	80	1,095	1,129	72	26	4,228	2,885	4,193	4,053	552	343
Surinam	13,030	9,465	18	12	--	--	23,083	17,333	--	--	--	--
Sweden	282	191	105	194	--	--	1,706	1,110	180	336	--	--
Switzerland	(2)	(2)	25	86	110	72	1,249	1,040	74	157	364	146
U.S.S.R	22	90	--	--	10,176	4,044	195	132	--	--	32,401	16,392
United Kingdom	6,631	4,135	264	464	2,565	1,437	9,126	5,881	1,149	1,229	3,396	2,081
Yugoslavia	551	358	5,581	5,770	--	--	15,382	11,169	11,499	12,485	--	--
Other	327	213	441	468	343	163	217	245	814	880	1,295	708
Total	434,119	316,873	61,354	65,079	54,806	27,586	575,350	439,570	87,560	96,312	85,714	46,166

[r] Revised.
[1] Includes circles, disks, bars, plates, sheets, pipes, etc.
[2] Less than 1/2 unit.

WORLD REVIEW

World primary aluminum production in 1976 increased 3% compared with the 1975 level as primary smelters restarted potlines that had been shut down in 1975 due to decreased demand. Stocks held by primary producers decreased steadily during the year.

Expansions of production capacity were completed in Brazil, Ghana, India, Japan, New Zealand, and Taiwan. Construction of additional smelting capacity was underway in Australia, Norway, Spain, Venezuela, and Yugoslavia. Plans for new primary aluminum reduction facilities were under consideration in Algeria, Brazil, Costa Rica, Dubai, Guyana, Iceland, Indonesia, Libya, Mexico, Paraguay, Saudi Arabia, Trinidad, and the U.S.S.R. Some projects in Australia, India, and Japan were postponed indefinitely.

Algeria.—The Soviet Union agreed to help finance the 154,000-ton-per-year primary aluminum smelter to be built near M'sila. Production at the $400 million facility was scheduled to begin in 1982. A 600-megawatt power station, technical assistance, and port improvements at Bejaia were included in the agreement. Alumina would be imported from Guinea and Jamaica.

Australia.—Comalco Ltd. postponed indefinitely plans for a 353,000-ton-per-year smelter at Gladstone, Queensland due to decreased demand and high construction costs. The company resumed work on a new potline at its Bell Bay, Tasmania smelter. Upon its scheduled completion in 1977, capacity of the facility would be 126,000 tons per year.

Bahrain.—Western Metals Corp. and Amalgamated Metals Corp. sold their share in Aluminium Bahrain Ltd., which operated a 132,000-ton-per-year smelter. Ownership of the facility at yearend included the Government of Bahrain (78%), Kaiser Aluminum & Chemical Corp. (17%), and Breton Investments (5%).

Brazil.—Cia. Vale do Rio Doce (CVRD) and the Light Metal Smelters Association (LMSA) announced an agreement to build a 350,000-ton-per-year primary aluminum smelter at Belem. The facility, which would be based on bauxite from the Trombetas project, would use hydroelectric power from the Tocantinas River. Japanese members of the consortium agreed to supply about $600 million of the estimated $1.3 billion cost of the project.

Reynolds International, Inc. and CVRD formed a new aluminum company, Vale do Sul Aluminio, S. A. (Valesul), to build an 88,000-ton-per-year smelter at Sepetiba Bay near Rio de Janeiro. The $250 million project was scheduled to begin production in 1979. Alumina would be supplied by Reynolds until the Alunorte bauxite-alumina project was completed.

Alcan Alumínio do Brasil, S.A. announced plans to expand its 35,000-ton-per-year smelter at Saramenha to 66,000 tons per year by 1980. Companhia Mineira de Alumínio doubled the capacity at Poços de Caldas to 66,000 tons per year and announced plans to further expand the plant to 99,000 tons per year. Alumínio do Brasil Nordeste, S.A., completed the expansion of its Aratü smelter to 31,000 tons per year.

Cameroon.—The Government of Cameroon announced that within the next 5 years development of bauxite deposits would start, the construction of an alumina refinery would be underway, and the tripling of the 61,000-ton-per-year primary aluminum smelter at Edea would be completed.

Canada.—Alcan Aluminium Ltd. primary aluminum smelters at Arvida, Quebec; Isle Maligne, Quebec; Beauharnois, Quebec; and Kitimat, British Columbia; were closed on June 3, 1976, due to a strike, and metal froze in the pots at the three Quebec smelters. Production was resumed later in the month at the Kitimat facility. A settlement between the company and the Federation des Syndicats du Secteur Aluminium (FSSA) in Quebec was reached November 14. Full production at the smelters was not expected until early 1977.

A strike occurred at the Alcan smelter at Shawinigan Falls, Quebec, in November, closing that plant through yearend.

Alcan announced plans to build a 200,000-ton-per-year smelter at Port Alfred, Quebec, where a 2,500-acre site was purchased in 1975. Design and engineering work was underway.

The Quebec Government announced plans to increase the fee charged private firms for use of public water resources used to generate hydroelectric power.

Costa Rica.—The National Aluminum Commission sought partners for a 100,000-

to 300,000-ton-per-year aluminum smelter to be built in Boruca. The project included a hydroelectric plant as well as the related infrastructure. Alcan, Kaiser, Alumax, Inc., and Martin Marietta Aluminum, Inc., have reportedly expressed interest in the $1.2 billion project.

Dubai.—The Government of Dubai and an international group of banks arranged a $200 million loan to help finance a proposed 132,000-ton-per-year smelter at Jebel Ali. British Smelter Construction would build the facility. Initial production was scheduled for 1979 with full capacity production scheduled for 1981. Southwire Corp. and Nissho Iwai Co. signed 12-year contracts to buy 80% of the aluminum production. Ownership of the facility consisted of the Government of Dubai (80%), Southwire Corp. (7.5%), Nissho Iwai (7.5%), and local interests (5%).

France.—The Government of France lifted price controls on domestic primary aluminum ingot at the beginning of May. Pechiney Ugine Kuhlmann increased the price of 99.5% purity ingot from 43.4 cents per pound to 45.6 cents per pound, and in July increased the price to 48.7 cents per pound, where it remained at yearend.

Germany, West.—Hamburger Aluminium-Werke G.m.b.H. announced that its 110,000-ton-per-year aluminum reduction facility in Hamburg operated at 100% of its rated capacity during the year. The smelter had operated at two-thirds of capacity since startup in 1973 due to various court actions involving environmental issues.

Swiss Aluminium Ltd. (Alusuisse) purchased the remaining 50% equity share in Leichtmetall G.m.b.H. from Metallgesellschaft A.G. Leichtmetall operated a 143,000-ton-per-year smelter at Essen.

Ghana.—Volta Aluminium Co. Ltd. completed expansion of the Tema smelter to 220,000 tons per year. Kaiser owned 90% of the facility, and Reynolds owned 10%.

Guyana.—Plans for a 165,000- to 240,000-ton-per-year smelter were under consideration. Power for the facility would be supplied by a 600- to 1,000- megawatt hydroelectric project on the Upper Mazaruni River. Production was scheduled for 1982.

Hungary.—The primary aluminum smelter and alumina refinery at Ajka were scheduled to be modernized between 1976 and 1980.

Iceland.—The Government of Iceland and Norsk Hydro A/S announced that preliminary studies were underway for a 110,000-ton-per-year smelter to be located in Eyjafjordur. The facility, to be based on geothermal power, was scheduled to come onstream in 1982.

India.—The ban on exports of primary aluminum was lifted due to decreased domestic consumption. During the fiscal year 1975-76, 15,000 tons of commercial grade metal were exported.

Bharat Aluminium Co. completed the expansion program at its Korba, Madhya Pradesh smelter, increasing the capacity of the facility to 55,000 tons per year. Power availability will determine whether expansion of the plant to 110,000 tons per year is feasible.

Indian Aluminium Co. Ltd. (Indal) increased the capacity of its Belgaum smelter to 83,000 tons per year. However, power shortages at yearend forced a 50% decrease in the plant's operating rate. The Indal smelter at Hirakud also experienced power shortages.

Hindustan Aluminium Co. announced plans to expand its primary smelter at Renukoot, Uttar Pradesh, by 27,000 tons per year.

The Indian Planning Commission postponed indefinitely plans for the 55,000-ton-per-year aluminum reduction facility at Ratnigiri, Maharashtra.

Indonesia.—The Governments of Indonesia and Japan agreed to lend Indonesia Asahan Aluminium Co. $87.5 million for equipment for the Asahan aluminum project. Production was scheduled for 1981 with an initial capacity of 83,000 tons per year. Expansion to 250,000 tons per year was planned.

Iran.—A second primary aluminum smelter to be built in conjunction with India and the U.S.S.R. was under consideration.

Italy.—The State corporation Ente Partecipazione Finanziamento Industria Manifattura (EFIM) announced that Alumetal S.p.A. would gradually phase out production at its primary smelters in Mori and Bolzano. Planned expansion of Alumetal's Fusina smelter was expected to compensate for the phased-out production capacity. Societá Alluminio Veneto per Azioni (SAVA) reportedly would phase out its smelter at Porto Marghera.

Japan.—Sumikei Aluminium Co. completed construction of a 50,000-ton-per-year primary aluminum smelter in Sakata, but production startup was postponed indefinitely. The facility is owned 45% by

Sumitomo Light Metal Industries, 20% each by Sumitomo Metal Industries, Ltd., and Sumitomo Chemical Co. Ltd., and 5% each by Sumitomo Bank, Sumitomo Shintaku, and Sumitomo Shoji Co.

Mitsui Aluminium Co. Ltd. brought its 23,000-ton-per-year expansion at Omuta, Miike onstream at yearend. Furukawa Aluminium Co. Ltd. postponed indefinitely plans for a 77,000-ton-per-year primary aluminum smelter in Mikuni, Fukui Prefecture. Mitsubishi Chemical Industries, Ltd. formed a new group, Mitsubishi Light Metal Industry, to handle primary aluminum production and sales.

Showa Light Metal Co., which was owned 50% by Showa Denko K.K. and 50% by the Fuyo group, took over management of the Chiba smelter in October and reportedly was to begin management of the Omachi and Kitikata aluminum reduction facilities in early 1977.

Libya.—The Government of Libya continued to discuss plans for an aluminum smelter with the Government of Yugoslavia which would have a 30% to 40% equity share in the project.

Mexico.—Alcan Project Services signed an agreement with Jalumex S.A. de C.V. to undertake a feasibility study for a 165,000-ton-per-year primary smelter. Alumina would be supplied from a planned alumina refinery at Manchester, Jamaica.

Netherlands.—Billiton N.V. withdrew from Holland Aluminium N.V., which operated a 106,000-ton-per-year smelter at Delfzijl.

New Zealand.—New Zealand Aluminium Smelters Ltd. began production in its new 42,000-ton-per-year potline at the Bluff smelter. Total capacity of the plant was 165,000 tons per year.

Norway.—Expansion of the Lista Aluminiumverk A/S (Elkem) primary aluminum plant at Lista to 90,000 tons was completed. A/S Ardal og Sunndal Verk (ASV) announced plans to complete expansion of its Ardal smelter to 203,000 tons per year by 1978. ASV also planned to build an aluminum foundry at the Hoyanger aluminum facilities with startup scheduled for 1979.

Paraguay.—Reynolds Metals Co. announced that it was considering participation in a 110,000-ton-per-year primary aluminum smelter. The $500 million project would use power from the Itaipu hydroelectric project and Reynolds would supply alumina.

Saudi Arabia.—Plans for a 220,000-ton-per-year smelter to be built at either Yambo or Jubail were included in the next 5-year plan.

Spain.—Alumínio de Galicia, S.A. (Alugasa), announced plans to expand primary aluminum production capacity at its La Coruña facility to 105,000 tons per year.

Construction of the San Cipriano aluminum smelter continued and Aluminium Pechiney signed agreements with Aluminio Español, S.A. to provide technical assistance for the project. Production at the 176,000-ton-per-year facility was scheduled to start in 1979.

Sweden.—The Ministry of Industry decided not to participate with Granges Aluminium A/B in the planned expansion of the Sundsvall smelter, resulting in postponement of the project.

Taiwan.—Taiwan Aluminium Corp. completed the expansion program at its Kaohsiung facility. The complex was expected to reach full capacity production of 75,000 tons per year by yearend.

Trinidad.—The Governments of Trinidad, Jamaica, and Guyana awarded Kaiser Aluminum & Chemical Corp. a contract to undertake a feasibility study for an 83,000-ton-per-year smelter in Trinidad. Jamaica and Guyana would each own 33% of the $165 million facility and would supply bauxite for the alumina refinery. Trinidad would own the remaining 34% and would supply natural gas. Plans called for eventual expansion to 193,000-ton-per-year capacity.

Turkey.—The U.S.S.R. undertook a feasibility study for the expansion of the Seydiseher aluminum complex. In addition to supplying technical assistance, the U.S.S.R. earmarked $50 million of a $1.2 billion loan to the Turkish Government for the expansion project.

U.S.S.R.—Pechiney Ugine Kuhlmann signed an agreement with the Soviet Union to build a 1.1 million ton-per-year alumina refinery in Siberia and also reached agreement to negotiate terms for a 550,000-ton-per-year smelter in Sayona-Sushenskaya.

Gerald Metals and Derby & Co. of the United Kingdom signed agreements with the Soviet Union to purchase about 30,000 tons each of primary aluminum ingot.

United Kingdom.—Kaiser Aluminum & Chemical Corp. announced plans to expand the Anglesey Aluminium Ltd. smelter at Holyhead by 55,000 tons per year.

The British Aluminium Co. smelter at Invergordon lost 6,000 to 8,000 tons of primary aluminum production due to a fire in the electrical rectifier.

Venezuela.—New Venalum, comprised of Corporacion Venezolana de Guayana (80%) and a Japanese consortium consisting of Sumitomo Metal Mining Co. Ltd., Mitsubishi Metal Corp., Kobe Steel Co., Marubeni Corp., and Showa Denko K.K., contracted to purchase 1 million tons of alumina over the next 5 years from Surinam through Montanore BV and from Jamaica through Reynolds Metals Co. The alumina would supply the 77,000-ton-per-year New Venalum smelter which was under construction at San Felix.

Yugoslavia.—The U.S.S.R. was awarded a contract to supply equipment and materials for the expansion of the Titograd smelter to 110,000 tons per year. Banque de Paris et des Pays-Bas agreed to provide the financing and Pechiney Ugine Kuhlmann would provide technical assistance.

The Tvornica Lakih Metals Boris Kidric smelter at Sibenik was under expansion to 110,000 tons per year to be completed in 1977. Construction started on the 94,000-ton-per-year smelter at Mostar.

An aluminum-waste-processing plant was under construction at Lozovac, the site of a phased-out primary smelter.

Table 14.—Aluminum: World production,[1] by country

(Thousand short tons)

Country	1974	1975	1976[p]
North America:			
Canada	1,125	978	690
Mexico	45	44	47
United States	4,903	3,879	4,251
South America:			
Argentina	1	26	50
Brazil	[r]139	134	149
Surinam	[r]38	49	[2]51
Venezuela	58	64	55
Europe:			
Austria	101	98	98
Czechoslovakia	55	48	55
France	434	422	424
Germany, East[e]	[r]65	[r]65	65
Germany, West	759	747	768
Greece	[r]164	149	148
Hungary	76	77	78
Iceland	[r]77	68	72
Italy	[r]238	210	228
Netherlands	277	288	282
Norway	[r]731	656	670
Poland[3]	112	113	110
Romania[4]	206	225	220
Spain	211	234	236
Sweden	91	85	90
Switzerland	96	87	86
U.S.S.R.[e]	1,580	[r]1,690	1,760
United Kingdom	[r]323	340	369
Yugoslavia	162	185	218
Africa:			
Cameroon	[r]52	57	63
Egypt	--	2	61
Ghana	173	158	162
South Africa, Republic of	83	84	86
Asia:			
Bahrain	130	128	135
China, People's Republic of[e]	165	180	220
India	142	184	234
Iran	54	56	34
Japan[5]	[r]1,232	1,117	1,013
Korea, Republic of	19	20	19
Taiwan	35	31	28
Turkey	--	18	39
Oceania:			
Australia	242	236	256
New Zealand	122	120	154
Total	[r]14,516	[r]13,352	13,774

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Output of primary unalloyed ingot unless otherwise specified.
[2]Exports.
[3]Includes secondary unalloyed ingot.
[4]Includes primary alloyed ingot.
[5]Includes production of superpurity aluminum (99.99% Al), apparently included in the reported total unalloyed ingot production, is as follows, in short tons: 1974—6,206; 1975—3,274; 1976—4,251.

Table 15.—Aluminum: World capacity, by country[1]

(Thousand short tons)

Country	1974	1975	1976
North America:			
Canada	1,210	1,175	1,175
Mexico	50	50	50
United States	4,916	5,021	5,193
South America:			
Argentina	40	40	66
Brazil	127	140	187
Surinam	73	73	73
Venezuela	55	55	55
Europe:			
Austria	102	102	101
Czechoslovakia	72	72	72
France	462	448	452
Germany, East	88	88	94
Germany, West	830	832	841
Greece	160	160	160
Hungary	69	69	69
Iceland	84	84	84
Italy	340	340	321
Netherlands	200	293	293
Norway	778	733	768
Poland	122	122	122
Romania	132	132	132
Spain	204	238	240
Sweden	95	95	94
Switzerland	100	105	104
U.S.S.R	1,578	2,140	2,555
United Kingdom	399	399	403
Yugoslavia	288	221	199
Africa:			
Cameroon	61	61	61
Egypt	36	110	110
Ghana	169	169	220
South Africa, Republic of	85	88	88
Asia:			
Bahrain	132	132	132
China, People's Republic of	220	270	270
India	290	289	330
Iran	50	55	55
Japan	1,434	1,492	1,627
Korea, Republic of	20	20	20
Taiwan	42	42	85
Turkey	66	66	66
Oceania:			
Australia	265	254	256
New Zealand	123	123	165
Total	15,567	16,398	17,388

[1]Detailed information on the individual aluminum reduction plants is available in a 2-part report which can be obtained from Chief, Division of Finance, Bureau of Mines Bldg. 20, Federal Center, Denver, Colo. 80225. Part One of "Primary Alumimum Plants, Worldwide," which costs $9.70 details location, ownership, and production capacity for 1976-83, and sources of energy and aluminum raw materials for foreign and domestic primary aluminum plants, including those in centrally planned economies. Part Two, which costs $2.55, summarizes production capacities for 1976-83, by smelter and country.

TECHNOLOGY

Conservation of energy and minimizing the impact of environmental standards and costs continued to be major research objectives of the aluminum industry. Results of recent studies presented at the Aluminum Association Energy Conservation Workshop were published.[3] Spurred by increasing energy costs, aluminum producers, fabricators, finishers, and end-product manufacturers have undertaken extensive investigations to reduce overall energy requirements. Much of the research centered around conservation of energy through recuperation of heat energy evolved from a processing step, such as melting or annealing, and returning it to the process to preheat the air and fuel used, or the metal itself.

A heat-wheel recuperator made of ceramic material for use at temperatures up to

[3]Light Metal Age. Aluminum Industry Conservation Workshop, Part 1. V. 34, No. 5-6, June 1976, pp. 5-16.

———. Aluminum Industry Conservation Workshop, Part 2. V. 34, No. 7-8, August 1976, pp. 5-15.

1,600°F reportedly was gaining acceptance in the aluminum industry. The heat wheel involves the passing of hot exhaust gases through one side of a slowly rotating wheel, absorbing the heat, while cold air is heated by passing it through the other side of the wheel in the opposite direction. The heated air can then be fed directly to a combustion furnace or used to preheat the metal directly. Alternating the direction of the air flow helps prevent buildup and subsequent plugging of the openings in the wheel by particulate matter. Efficiencies of the heat wheel approach 70%. At one aluminum billet heating furnace facility, installation of ceramic heat wheels reportedly reduced fuel consumption from 1.7 cubic feet of natural gas per pound of aluminum to 0.65 cubic foot per pound. Preheating of combustion air by a ceramic heat wheel in another facility reportedly saved 60% of the fuel used per heating cycle and shortened the cycle by about 25%.

Under a Bureau of Mines contract, Battelle Columbus Laboratories reviewed and assessed the development of alternative aluminum production processes that might conserve energy.[4] A 20% energy savings was believed possible by replacing the conventional Hall-Heroult process for producing primary aluminum which is based on the electrolysis of aluminum oxide by the Alcoa process. The Alcoa process is based on electrolysis of aluminum chloride. However, direct operating costs of the Alcoa process were estimated to be about 10% higher than the Hall-Heroult process. Other processes evaluated used more energy. In another study the energy savings of the Alcoa process were estimated to be 30% in comparison with the Hall-Heroult process and production costs of the two processes were almost the same.[5]

Background information on the impact of air pollution control standards on the primary aluminum industry was summarized in a report.[6] The report stated that, based on an economic analysis and other available information, the following conclusions could be drawn (cost data are in 1975 constant dollars):

(1) Growth in total domestic primary aluminum capacity and supplies will not be adversely affected by the promulgated standards.

(2) The promulgated standards will accelerate the current industry trend to prebake cells and away from Soderberg cells.

(3) The standards are expected to result in an investment cost increase at new primary aluminum plants of approximately $95 per ton of capacity (first quarter of 1975) or approximately 8% of the cost of a new uncontrolled plant.

(4) Existing control levels are estimated to require average investment costs of approximately $65 per ton of aluminum capacity. Viewed as an incremental cost, the promulgated standards would require an investment cost increase over the current industry average of $30 per ton of capacity.

(5) The standards are expected to result in an annual cost increase at new primary aluminum plants of approximately $16 per ton, or 0.82 cent per pound of aluminum produced (assuming no existing State control requirements would apply). A total annual cost increase of approximately $31 million in the fifth year is expected to result from the imposition of the standards (making the same assumption). If the entire cost increase were passed on to consumers, it would amount to a price increase of 2.1% of current prices. Allowing a pretax return on the pollution control capital of 20% would result in a total price increase of approximately 1.8 cents per pound of aluminum, or 4.6% of current prices.

(6) The level of cost for control of fluoride emissions to the air currently being incurred by the industry averages approximately $14 per ton of aluminum, or 0.7 cent per pound.

(7) The standards would result in the reduction of fluoride emissions to the air of approximately 48 pounds of fluoride per ton of aluminum produced (96%) in the case of an uncontrolled plant and 11 pounds per ton of aluminum produced (85%) in the case of a plant employing the industry's current average level of control.

(8) No plant closings or production curtailments are expected to result from the imposition of the standards.

(9) The energy requirements for air pollution control systems currently in use at existing primary aluminum plants and the

[4] Battelle Columbus Laboratories. Energy Use Patterns in Metallurgical and Nonmetallic Mineral Processing (Phase 9-Areas Where Alternative Technologies Should be Developed to Lower Energy Use in Production of High-Priority Commodities). BuMines Open File Rept. 117(1)-76, 1976, pp. 10-19; available for consultation at the Bureau of Mines libraries in Tuscaloosa, Ala., College Park, Md., Twin Cities, Minn., Rolla, Mo., Boulder City, Nev., Reno, Nev., Albany, Oreg., Salt Lake City, Utah; and the Central Library, U.S. Department of the Interior, Washington, D.C.; and from National Technical Information Services, Springfield, Va., PB 261 150/AS.

[5] U.S. Environmental Protection Agency. Environmental Considerations of Selected Energy Conserving Manufacturing Process Options: Alumina/Aluminum Industry Report, V. 8, EPA-600/7-76-034h, December 1976, 139 pp.

[6] U.S. Environmental Protection Agency. Background Information for Standards of Performance: Primary Aluminum Industry, Supplemental Information, v. 3, EPA 450/2-74-020c, January 1976, 47 pp.

energy requirements to meet the 1983 Environmental Protection Agency effluent guidelines at these plants have been estimated to total 285 kilowatt-hours per ton of aluminum produced (industry-wide average). The energy requirements for air pollution control for a new prebake plant (only prebake plants are expected to be built) have been estimated at 211 kilowatt-hours per ton of aluminum produced.

In another study of the energy used for pollution controls and the environmental impact of production of primary and secondary aluminum metal, the total cost of pollution controls (1975 basis) was estimated at $10.16 to $13.59 per metric ton of primary aluminum and $4.98 to $10.10 per metric ton for secondary.[7]

Information on pollution control performance standards for primary[8] and secondary[9] sources of aluminum was published.

In a patented process, developed by the Bureau of Mines,[10] aluminum metal is recovered from processed wastes such as dross and beverage-can scrap without use of a flux. Aluminum is recovered by heating the wastes to a temperature above the melting point of aluminum (about 660°C) but below about 800°C while maintaining the wastes under a protective gaseous atmosphere which is substantially inert to molten aluminum. Argon is preferred as the protective atmosphere. After the aluminum-contained in the wastes has been melted, the heated material is agitated gently to agglomerate the molten aluminum and to cause it to settle and collect in the bottom of the containment vessel. Molten aluminum is then removed from the vessel leaving a substantially inert residue.

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[7]U.S. Environmental Protection Agency. Environmental Impacts of Virgin and Recycled Steel and Aluminum. EPA-530/SW-117c, 1976, 115 pp.; available from National Technical Information Service, Springfield. Va.

[8]U.S. Environmental Protection Agency. Air Programs; Performance Standards for New Stationary Sources, Primary Aluminum Industry. Part 3. Federal Register, v. 41, No. 242, Dec. 15, 1976, pp. 3826-3830.

[9]U.S. Environmental Protection Agency. Nonferrous Metals Manufacturing Point Source Category, Interim Rulemaking. Part 3. Federal Register, v. 41, No. 242, Dec. 15, 1976, pp. 54850-54854.

[10]Montagna, D. (assigned to U.S. Secretary of the Interior). Fluxless Recovery of Metallic Aluminum From Wastes. U.S. Pat. 3,999,980, Dec. 28, 1976.

Antimony

By John A. Rathjen[1]

The U.S. antimony industry during 1976 registered increases in all phases of activity with the exception of domestic mine production. Consumption rose to 15,337 tons, reflecting increased demand in the chemical area, particularly as a flame retardant. Smelter and secondary production and imports rose, but exports were virtually unchanged. Industry stocks also rose slightly, increasing above the record high level established in 1975.

Domestic mine production dropped sharply as a result of a strike at the Sunshine mine in Idaho. The strike began in March and was in effect for the remainder of the year.

The generally increased level of business activity during the first half of the year precipitated a price rise in September to $1.79 per pound from $1.60 per pound, which had prevailed since June 1975.

Legislation and Government Programs.—Government stocks of antimony remained at 40,700 tons. On October 1, 1976, the Federal Preparedness Agency (FPA), a part of the General Services Administration (GSA), established a new goal for antimony of 20,130 tons. This action created a surplus of 20,570 tons, but Congressional approval is required for disposal. Antimony remained on the list of commodities eligible for exploration assistance under the program administered by the Office of Minerals Exploration (OME). However, funds for exploration projects have not been requested from Congress since fiscal year 1974.

Federal income tax laws under the Tax Reform Act of 1969 provided a percentage depletion allowance of 22% for domestic production and 14% for U.S. production from foreign sources.

[1]Mineral specialist, Division of Nonferrous Metals.

Table 1.—Salient antimony statistics

(Short tons)

	1972	1973	1974	1975	1976
United States:					
Production:					
Primary:					
Mine	489	545	661	886	283
Smelter[1]	13,344	17,206	16,657	12,189	14,618
Secondary	22,428	24,062	23,570	17,964	19,799
Exports of ore, metal and alloys	121	515	871	340	341
Imports for consumption (antimony content)	23,743	21,265	22,119	18,706	21,770
Consumption[1]	16,124	20,613	18,041	12,987	15,337
Price: New York, average cents per pound	59.00	68.50	181.76	176.58	165.26
World: Production	73,986	76,920	r79,113	r76,700	76,286

rRevised.
[1]Includes primary antimony content of antimonial lead produced at primary lead refineries.

DOMESTIC PRODUCTION

Mine Production

Domestic mine production from two mines totaled 283 tons during 1976, a decrease of 68% from that of 1975. A number of companies were involved in feasibility studies and development programs in Nevada and Alaska. The Sunshine mine, operated by the Sunshine Mining Co. in the Coeur d'Alene district of Idaho, contributed 133 tons to the total U.S. output. Low production was the result of a prolonged strike which began March 11 and continued throughout the year. Antimony was produced at the Sunshine mine from the treatment of tetrahedrite, a complex silver-copper-antimony sulfide mineral, one of the principal metal-bearing ores in the Kellog area.

Production at the Babbitt mine-mill-smelter complex operated by the U.S. Antimony Corp. at Thompson Falls, Mont., dropped considerably to 150 tons of antimony in 1976, as compared with 273 tons in 1975. This decline was primarily attributed to the continuing development of the mine and a change in the end product mix. Stibnite, the most common of the antimony minerals, is the primary source of antimony at this operation.

Byproduct antimonial lead, produced in the refining of primary lead from domestic ores, increased 32% to 355 tons in 1976 compared with 268 tons in 1975.

Table 2.—Antimony mine production and shipments in the United States

(Short tons)

Year	Antimony concentrate	Antimony	
		Produced	Shipped
1972	2,072	489	547
1973	2,468	545	494
1974	3,217	661	593
1975	4,505	886	966
1976	1,111	283	310

Smelter Production

Primary.—The total production of primary antimony products in 1976 was 14,618 tons, an increase of about 20% compared with output in 1975. Virtually all of the increase was reflected in increased production of oxide, which was 2,738 tons higher than production of 7,890 tons in 1975. Metal production decreased 5% to 3,102 tons during 1976 compared with 3,254 tons produced in 1975.

The major producers of antimony oxide were Harshaw Chemical Co., Gloucester City, N.J.; Chemetron Corp., Cuyahoga Heights, Ohio; M&T Chemicals Inc., Baltimore, Md.; and ASARCO Inc., Perth Amboy, N.J. During 1976 McGean Chemical Co. Inc., Cleveland, Ohio, resumed commercial activity in the antimony oxide marketplace. Producers of antimony metal included NL Industries, Inc., Laredo, Tex.; U.S. Antimony Corp., Thompson Falls, Mont.; and Sunshine Mining Co., Kellog, Idaho. During 1976 ASARCO continued planning and engineering studies for the antimony refinery to be built at El Paso, Tex. It was expected that operating plans would be announced during 1977.

Table 3.—Primary antimony produced in the United States

(Short tons, antimony content)

Year	Class of material produced					Total
	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1972	3,837	8,343	232	201	731	13,344
1973	2,859	11,273	92	1,839	1,143	17,206
1974	3,030	10,445	54	2,066	1,062	16,657
1975	3,254	7,890	--	595	450	12,189
1976	3,102	10,628	--	191	697	14,618

Table 4.—Byproduct antimonial lead produced at primary lead refineries in the United States

(Short tons)

Year	Gross weight	Antimony content: From domestic ores[1]	From foreign ores[2]	From scrap	Total: Quantity	Total: Percent
1972	15,051	516	215	319	1,050	7.0
1973	15,455	731	412	24	1,167	7.6
1974	12,513	658	404	35	1,097	8.8
1975	6,029	268	182	117	567	9.4
1976	6,743	355	342	33	730	10.8

[1]Includes primary residues and a small quantity of antimony ore.
[2]Includes foreign base bullion and small quantities of foreign antimony ore.

Secondary.—Production of antimony from secondary sources increased slightly to 19,799 tons, an increase of 1,835 tons above that of 1975. Of this, 16,498 tons, or 83% of the total metal, was recovered by treating battery scrap. It is expected that this source of antimony will increase over the next 3 years as the automotive battery industry changes over to new antimony-free and low-antimony grid systems. Additional quantities of antimony are recovered by processing various secondary materials such as type metal, old bearings, drosses, cable sheathing, and other items.

Table 5.—Secondary antimony produced in the United States, by kind of scrap and form of recovery

(Short tons, antimony content)

Kind of scrap	1975	1976	Form of recovery	1975	1976
New scrap:			In antimonial lead[1]	14,768	16,498
Lead-base	1,905	2,116	In other lead alloys	3,187	3,294
Tin-base	39	26	In tin-base alloys	9	7
Total	1,944	2,142	Total	17,964	19,799
			Value (millions)	$63.4	$65.4
Old scrap:					
Lead-base	16,007	17,642			
Tin-base	13	15			
Total	16,020	17,657			
Grand total	17,964	19,799			

[1]Includes 117 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1975 and 33 tons in 1976.

CONSUMPTION AND USES

Domestic consumption of primary antimony in 1976 increased by 2,350 tons to 15,337 tons. A loss of 747 tons in the metal products category was more than offset by gains in nonmetal and flame retardant applications, which combined was 10,437 tons, an increase of 42% over that of 1975. The decline in the use of primary antimony metal products was attributed mainly to the changeover in automotive battery grid systems. The adoption of calcium-tin and low-antimony alloys reduced the demand for primary metal, because recovery from secondary smelting was more than adequate to meet requirements.

Use of antimony trioxide as a flame retardant increased by 1,753 tons to a total of 5,552 tons in 1976, establishing a record high for this application. Use of primary antimony in nonmetal products increased 38% to 4,885 tons.

Table 6.—Industrial consumption of antimony in the United States

(Short tons, antimony content)

Year	Class of material consumed						
	Ore and concentrate	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	Total
1972	1,226	5,473	8,389	104	201	731	16,124
1973	582	5,824	10,970	255	1,839	1,143	20,613
1974	1,032	4,362	9,457	62	2,066	1,062	18,041
1975	369	4,229	7,311	33	595	450	12,987
1976	640	3,375	10,397	37	191	697	15,337

Table 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1972	1973	1974	1975	1976
Metal products:					
Ammunition	64	122	121	239	63
Antimonial lead	6,149	8,027	7,251	4,568	3,861
Bearing metal and bearings	559	527	476	402	405
Cable covering	19	12	16	23	19
Castings	39	65	31	18	24
Collapsible tubes and foil	20	12	18	9	23
Sheet and pipe	108	97	69	60	74
Solder	177	191	205	133	188
Type metal	142	134	107	75	79
Other	105	104	135	120	164
Total	7,382	9,291	8,429	5,647	4,900
Nonmetal products:					
Ammunition primers	23	18	11	14	13
Fireworks	4	5	11	10	12
Ceramics and glass	1,695	1,917	1,384	989	1,260
Pigments	644	644	460	321	415
Plastics	2,391	2,920	1,431	1,091	1,277
Rubber products	587	693	664	458	578
Other	1,118	2,219	1,268	658	1,330
Total	6,462	8,416	5,229	3,541	4,885
Flame retardant:[1]					
Plastics	2,280	2,906	2,711	2,501	3,777
Pigments			172	92	183
Rubber			252	172	199
Adhesives			231	126	141
Textiles			980	748	1,055
Paper			37	160	197
Total	2,280	2,906	4,383	3,799	5,552
Grand total	16,124	20,613	18,041	12,987	15,337

Note: The 1972 and 1973 flame retardant values (2,280 and 2,906) are bracketed across all flame retardant items.

[1]Flameproofing chemicals and compounds shown separately by use starting 1974.

STOCKS

Industry stocks of antimony climbed for the fourth consecutive year to a record total of 15,070 tons at the end of 1976. There was a decline in stocks of antimony contained in ores and concentrates. However, this was offset by gains in metal and oxide holdings which climbed 282 and 674 tons, respectively. This change in inventory mix is expected to continue as more countries initiate value added programs, wherein they upgrade raw materials to realize higher return on investment.

Table 8.—Industry stocks of primary antimony in the United States, December 31

(Short tons, antimony content)

Stocks	1972	1973	1974	1975	1976
Ore and concentrate	3,562	5,585	6,275	8,364	7,899
Metal	1,332	1,540	809	1,380	1,662
Oxide	3,179	2,074	3,732	3,886	4,560
Sulfide	182	31	35	32	31
Residues and slags	176	526	549	921	475
Antimonial lead[1]	191	322	294	374	443
Total	8,622	10,078	11,694	14,957	15,070

[1]Inventories from primary sources at primary lead refineries only.

PRICES

The New York price for RMM brand 99.5% antimony metal was quoted at $1.60 per pound through September 16, at which time NL Industries increased its quotation to $1.75 per pound f.o.b. Laredo, Tex. The effective freight differential was increased from 2 cents to 3 cents per pound f.o.b. New York for RMM metal. This remained in effect through the end of the year. Antimony trioxide followed metal pricing very closely beginning the year at $1.65 per pound and increasing on October 1 to $1.80 per pound. The New York dealer price for foreign metal, which was quoted in a range of $1.35 to $1.45 per pound in January, rose to $1.70 to $1.80 per pound in August, but fell late in the year to $1.35 to $1.40 per pound. The European market quotation for lump ore, on a 60% antimony basis increased during 1976 from a low of $20 to $22 per metric ton unit, c.i.f. to $25.50 to $27.50, at yearend.

Table 9.—Antimony price ranges in 1976

Type of antimony	Price per pound
Domestic metal[1]	$1.58-$1.75
Foreign metal[2]	1.35- 1.80
Antimony trioxide[3]	1.65- 1.80

[1]RMM brand, f.o.b., Laredo, Tex.
[2]Duty-paid delivery, New York.
[3]Quoted in Metals Week.

FOREIGN TRADE

Exports of antimony ore, metal, alloys, and scrap totaled 341 tons in 1976, virtually unchanged from those of 1975. Canada received 30% of the shipments; Poland and Japan, 16% each. The balance was shipped in small parcels to 17 additional countries. Exports of antimony oxide rose to 324 tons, an increase of 36 tons from that of 1975. Canada received 43% of the total, and the remainder was distributed among 17 other countries.

Imports of antimony in all forms totaled 21,770 tons (metal content), an increase of 16% over the 1975 total. Antimony ore receipts increased 20% to 10,023 tons. Antimony oxide receipts, which totaled 11,611 tons, increased 17% above that of 1975. Imports of both antimony metal and liquated material declined from the 1975 level.

Four countries supplied over 89% of antimony oxide imports during 1976: The Republic of South Africa, 6,005 tons; the United Kingdom, 1,623 tons; France, 1,464 tons; and the People's Republic of China, 1,288 tons. Both France and the People's Republic of China more than doubled their shipments of oxide in 1976, compared with those of 1975, indicating a continuing effort by the producing countries to upgrade the value of their production. Receipts of antimony in ores and concentrates increased by 1,703 tons in 1976 to a total of 10,023 tons. A sharp drop in shipments from Mexico and Guatemala was more than offset by increased tonnage from the Republic of South Africa and Canada. Imports of refined metal decreased slightly to 2,083 tons, a loss of 29 tons from the 1975 total; however, the pattern of imports changed considerably from that of 1975. Belgium-Luxembourg, the People's Republic of China, Italy, and Japan, which cumulatively shipped 1,144 tons in 1975, supplied only 649 tons in 1976. This 495-ton decline was essentially offset by the increased tonnage from Bolivia and Yugoslavia, which together shipped 558 tons above their combined 1975 total.

Table 10.—U.S. imports for consumption of antimony, by country

Country	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Antimony metal, including needle or liquated:[1]				
Belgium-Luxembourg	408	$1,064	392	$611
Bolivia	42	111	236	743
Canada	3	30	1	36
Chile	13	37	14	36
China, People's Republic of	421	1,361	209	613
France	23	54	--	--
Germany, West	(2)	17	1	16
Italy	231	637	22	70
Japan	127	332	44	131
Malaysia	--	--	11	30
Mexico	294	807	273	443
Netherlands	11	29	--	--
Singapore	11	20	--	--
Spain	56	141	41	108
Taiwan	22	73	--	--
Thailand	111	257	99	284
Turkey	22	5	--	--
United Kingdom	204	462	230	462
Yugoslavia	187	495	551	1,532
Total	2,186	5,932	2,124	5,115
Antimony oxide:				
Belgium-Luxembourg	214	788	350	965
Bolivia	--	--	110	293
China, People's Republic of	547	1,896	1,288	3,441
France	572	1,675	1,464	4,198
Germany, West	20	44	22	69
Hong Kong	17	67	--	--
Italy	(2)	(2)	20	53
Japan	569	1,773	597	1,638
Netherlands	61	199	50	143
South Africa, Republic of	6,587	1,873	6,005	1,504
Sweden	(2)	1	--	--
Switzerland	--	--	(2)	(2)
Taiwan	193	770	82	218
United Kingdom	1,128	3,502	1,623	4,507
Total	9,908	12,588	11,611	17,029

[1]Includes needle or liquidated (value in thousands): 1975-Belgium-Luxembourg 21 tons ($70), the United Kingdom 31 tons ($97), the People's Republic of China 22 tons ($88); 1976-Belgium-Luxembourg 18 tons ($53), the United Kingdom 23 tons ($76).

[2]Less than 1/2 unit.

Table 11.—U.S. imports for consumption of antimony ore, by country

Country	1975 Gross weight (short tons)	1975 Antimony content (short tons)	1975 Value (thousands)	1976 Gross weight (short tons)	1976 Antimony content (short tons)	1976 Value (thousands)
Australia	110	71	$169	--	--	--
Belgium-Luxembourg	600	308	783	--	--	--
Bolivia	2,639	1,540	4,242	3,179	1,992	$3,820
Canada	1,012	637	1,426	1,756	1,091	1,949
Chile	--	--	--	711	411	804
Colombia	287	39	48	219	91	112
Guatemala	2,321	1,127	873	949	474	384
Honduras	306	153	136	--	--	--
Mexico	9,567	2,218	1,730	6,625	1,513	2,458
South Africa, Republic of	2,986	1,792	4,194	7,495	4,446	7,378
Thailand	908	435	934	11	5	6
Total	20,736	8,320	14,535	20,945	10,023	16,911

Table 12.—U.S. imports for consumption of antimony

Year	Antimony ore: Gross weight (short tons)	Antimony ore: Antimony content (short tons)	Antimony ore: Value (thousands)	Needle or liquated: Gross weight (short tons)	Needle or liquated: Value (thousands)	Antimony metal[1]: Gross weight (short tons)	Antimony metal[1]: Value (thousands)	Antimony oxide: Gross weight (short tons)	Antimony oxide: Value (thousands)
1974	31,330	14,655	$20,866	86	$271	2,203	$7,550	6,269	$15,580
1975	20,736	8,320	14,535	74	255	2,112	5,677	9,908	12,588
1976	20,945	10,023	16,911	41	129	2,083	4,986	11,611	17,029

[1]Does not include alloy containing 83% or more antimony.

WORLD REVIEW

World mine production of antimony in 1976, 76,286 tons, showed a nominal decline of 414 tons from that of 1975. The Republic of South Africa reported a major drop in production to 11,890 tons, a loss of 5,663 tons from that of 1975. This decline was balanced by increased production in Bolivia, Thailand, the Republic of Korea, Morocco, Peru, and Guatemala, which collectively increased production by 5,814 tons. Bolivia was the world's largest producer with 16,873 tons, an increase of 3,737 tons.

Australia.—Antimony production in Australia declined in 1976 to 1,818 tons, a drop of 14% from that of 1975. The decrease was attributed mainly to curtailed production by Australian Antimony Corp. NL at its new mine near Dorrigo on the north coast of New South Wales. The mine was closed for economic reasons, but it was being maintained on a standby basis.

The closedown at Dorrigo was partially offset by startup of the Blue Spec antimony-gold mine near Nullagine in Western Australia. The Blue Spec mine, which is operated as a joint venture by Metramor Minerals Ltd., and Australian Anglo-American Ltd., is expected to produce about 1,400 tons of antimony per year.

Bolivia.—During 1976, Bolivia emerged as the world's largest producer of antimony, passing the Republic of South Africa which had previously been the leader. A combined total of 16,873 tons of antimony (metal content), was produced in Bolivia at a new smelter. The smelter, which was completed in December 1975, is located at Vinto, near the city of Oruro, and is operated by Empresa Nacional de Fundiciones (ENAF). The plant had been scheduled for full production in 1976, but startup problems prevented maximum utilization through most of the year. The design capacity of the smelter provides for treatment of 10,300 tons of high-grade concentrates containing 63.2% antimony, which will yield approximately 4,700 tons of antimony metal, and 1,100 tons each of antimony alloys and antimony trioxide.

Since Bolivian mine production exceeds smelter capacity it is expected that Bolivia will continue to sell antimony ore and concentrate throughout the world.

Canada.—Antimony metal was produced in Canada as a byproduct of lead smelting and refining. It was recovered chiefly in the form of antimonial lead by Cominco Ltd. at its smelter and refinery at Trail, British Columbia, and Brunswick Mining and Smelting Corp., which operated a lead smelter at Belledune, New Brunswick.

Consolidated Durham Mines and Resources Ltd. operated Canada's only antimony mine. The Lake George property near Fredrickton, New Brunswick, has a mill capacity of 400 tons per day. Concentrates average slightly over 65% antimony, and are shipped mainly to Europe, with small quantities going to the United States and Japan.

Con-Am Resources announced a preliminary feasibility study of its Carbon Hill antimony property near Whitehorse, Yukon Territory. Work carried out on the property from 1964-67 by Yukon Antimony outlined a possible reserve of 140,000 tons of ore grading 4% antimony. If the reserves are confirmed, the company plans to install a 200-ton-per-day plant.

China, People's Republic of.—Estimated production of 13,000 tons of antimony established the People's Republic of China as the world's second largest producer. The bulk of Chinese antimony was produced in

Table 13.—Antimony: World production (content of ore unless otherwise indicated), by country

(Short tons)

Country	1974	1975	1976[p]
North America:			
Canada[e 1]	[r]1,560	[r]2,020	2,190
Guatemala	480	944	1,235
Honduras	149	114	129
Mexico[2]	2,653	3,458	2,806
United States	661	886	283
South America:			
Argentina	[r]5	3	[e]3
Bolivia	[3]14,396	[3]13,136	[4]16,873
Peru (recoverable)	[r]349	305	665
Europe:			
Austria (recoverable)	551	561	588
Czechoslovakia	830	[r]830	830
Italy	1,297	1,113	1,119
Spain	148	88	168
U.S.S.R.[e]	8,000	8,300	8,500
Yugoslavia	2,434	2,406	[e]2,110
Africa:			
Algeria	66	66	[e]66
Morocco	2,029	1,160	1,560
Rhodesia, Southern[e]	330	330	330
South Africa, Republic of	[r]16,721	17,553	11,890
Asia:			
Burma[e]	[r]380	[r]490	520
China, People's Republic of[e]	13,000	13,000	13,000
Korea, Republic of	[r]9	44	477
Malaysia (Sarawak)	[r]280	276	[e]275
Pakistan[e]	36	33	33
Thailand	4,669	3,454	4,047
Turkey	[r]6,530	4,010	4,771
Oceania: Australia[5]	[r]1,550	2,120	1,818
Total	[r]79,113	76,700	76,286

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Estimated on the basis of value of production.
[2]Antimony content of ores for export plus antimony content of antimonial lead and other smelter products produced.
[3]Production by COMIBOL plus exports by medium and small mines and so-called other producers.
[4]Total national production.
[5]Antimony content of antimony concentrates, lead concentrates, and zinc concentrates.

southwestern Hunan Province, with the largest output from the Hsikwangshan mine. This mine has been estimated to contain reserves in excess of 1.5 million tons of antimony. Antimony ore is also mined in Kwangtun Province. Material produced in the People's Republic of China is smelted and refined near the city of Changshan in Hunan Province.

South Africa, Republic of.—Consolidated Murchison Ltd. continued as the single significant producer of antimony in South Africa with a total output of 11,890 tons, 32% below the output in 1975. The decline was attributed to lower ore grades at the mill, and production of high-arsenic material, which has been set aside for future processing. Mining operations were conducted in the Letaba district of the Transvaal. Most of the production was in the form of concentrates; however, there was a substantial amount of cobbed ore which was recovered and shipped as a direct smelting material. During 1976 there was a considerable drop in production to 10,625 tons of antimony contained in combined concentrate and cobbed ore compared with 15,048 tons produced in 1975. Total shipments, however, were up in 1976 to 13,725 tons of contained antimony, an increase of 1,124 tons over that of 1975, reflecting a draw down on raw material inventories, which had become large.

Thailand.—Production of antimony increased 17% to 8,637 tons of concentrates. About 480 tons of refined metal was also produced during the year. A portion of the increase was attributed to the reopening of the Phahad mine in Phrae Province. The mine, which had been shut down in 1970, was modernized and became the first mechanized underground antimony operation in Thailand. Planned capacity was established at 150 tons per month of hand-cobbed ore and gravity concentrates. Phluang Thong Thai Co. (PTT), a consortium of local interests and the Hochschild group, was the owner-operator.

The Hibino Metal Industrial Corp. of Japan reported that it would begin operating a new property near Chiang Mai. Planned production would be 100 tons per month of 60% concentrate.

Yugoslavia.—A new mine began production of antimony concentrate at Kopanik-Raiceyoj Gori in Serbia. The mine is operated by the mining and metallurgical enterprise Aajaca Rudarsko—Topionicarski Basen (Aajaca). Initial annual production rate was approximately 45,000 tons of ore, yielding about 1,500 tons of concentrate. It is planned to expand production eventually to about 300,000 tons of ore per year, a move that will add significantly to the world mine capacity of antimony and will place Yugoslavia among the world's major producers.

Asbestos

By R. A. Clifton[1]

Shipments of asbestos (mostly chrysotile) in 1976 from mines in the United States increased 16% over those in 1975. With the continued high demand for domestic asbestos, all previously operating mines, plus the newly reopened Calaveras (Pacific) mine, were producing at capacity. Imports were 22% higher than those in 1975 because of recovery from the Canadian strike, but demand may still be depressed owing to the economic recession and/or environmental factors.

Canadian production in 1976 was 47% more than that for 1975, and shipments from Canada to the United States were 23% more than those in 1975. Imports from the U.S.S.R. were nearly 2% of total U.S. imports, and those from the Republic of South Africa accounted for 3%.

Table 1.—Salient asbestos statistics

	1972	1973	1974	1975	1976
United States:					
Production (sales) ---------- short tons--	131,663	r150,036	r109,091	98,654	114,842
Value ------------- thousands--	$13,409	$16,288	$13,759	$14,220	$23,693
Exports and reexports (unmanufactured) ------------- short tons--	58,624	66,442	61,723	36,447	46,923
Value ------------- thousands--	$9,051	$9,342	$9,192	$10,667	$12,791
Exports and reexports of asbestos products (value) ------------- do----	$32,110	$40,777	$60,396	$60,776	$60,572
Imports for consumption (unmanufactured) ------------- short tons--	735,515	792,473	766,164	538,553	657,851
Value ------------- thousands--	$87,732	$98,914	$123,822	$111,011	$142,145
Released from stockpile (unmanufactured) -------- short tons--	13,174	6,761	28,851	6,877	552
Consumption, apparent[1] --------- do----	821,728	882,908	845,825	607,637	726,322
World: Production ----------------- do----	4,163,675	r4,613,717	4,582,320	r4,564,130	5,565,910

rRevised.
1Measured by quantity produced, plus imports, plus stockpile releases, minus exports.

Legislation and Government Programs.—As of December 31, 1976, the Occupational Safety and Health Administration (OSHA) had not yet set a date for the mandatory public hearing on its proposed revision of the asbestos standard for manufacturing. The regulated allowable exposure to asbestos had been lowered on July 1 from 5.0 to 2.0 fibres per cubic centimeters (f/cm^3); the OSHA proposal was for a permissible-exposure level of 0.5 f/cm^3. However, the National Institute of Occupational Safety and Health (NIOSH) recommended a still lower level. In a December 15, 1976 letter to OSHA, the Director of NIOSH recommended a level of 0.1f/cm^3. Thus, during 1976, changes made and proposed represent a fiftyfold reduction in the regulated allowable exposure to asbestos in the manufacturing workplace.

The President signed the Toxic Substances Control Act into law on October 11, 1976, too late to allow meaningful evaluation of its impact on the asbestos industry.

[1]Physical scientist, Division of Nonmetallic Minerals.

New stockpile goals were announced by the Federal Preparedness Agency (General Services Administration) in a press release dated November 24, 1976. The announced stockpile goal for chrysotile was zero; and for amosite, the goal was 26,291 short tons. Crocidolite was not named as a strategic material. As shown in table 2, there were few asbestos sales from the national stockpile in 1976.

Table 2.—Stockpile goals and Government inventories as of December 31

(Short tons)

	Stock-pile goals	Total inventories 1975[r]	Total inventories 1976	Sales of excesses, 1976
Amosite	26,291	45,293	42,623	2,670
Chrysotile	None	10,956	[1]10,955	--
Crocidolite	None	2,478	[1]2,474	--
Total	--	58,727	56,052	2,670

[r]Revised.
[1]Adjusted figure, Federal Preparedness Agency.

Environmental Impact.—Disruptions in the marketplace in 1976 left consumption of asbestos by U.S. industry at 82% of the 1973 alltime high. These disruptions cannot be blamed entirely on either the economy or environmental factors. With the possible exception of the textile portion of the industry, much of the decline in consumption can be argued to have come from recession-related factors. The decrease in exports of asbestos-textile products and the increase in imports lend validity to this position. UNIROYAL Inc., announced that its Fiber and Textile Div. would no longer be manufacturing asbestos-containing textiles after July 1, 1976, because of marginal profitability and the cost of full compliance with OSHA regulations.

The costs of environmental compliance to asbestos producers, however, have readily been absorbed by consumers. The Vermont Asbestos Group announced that the purchase costs of their Lowell mine, formerly a GAF Corp. property, had been recouped in less than 2 years. The management of Calaveras Asbestos Corp. stated that the firm was profitable after 1 year of operation.

DOMESTIC PRODUCTION

Mines in the United States shipped 16% more asbestos in 1976 than in 1975. Value was 67% higher than in 1975. Three States produced asbestos; California, was the leader, with 68%, followed by Vermont and Arizona. There was a possibility of some production from North Carolina. Total output was 114,842 tons valued at $23,693,000.

California led the increase in production. Reopening of the Calaveras Asbestos Corp. mine (formerly Pacific Asbestos Corp.) led to a production increase 39% above the 1975 State total. The value increased 160% over the 1975 value of the fiber. By yearend, Calaveras Asbestos Corp. was in full operation. At yearend mines were also active on the Joaquin Ridge near Coalinga. Atlas Asbestos Corp. worked its Santa Cruz mine in Fresno County and Union Carbide Corp. operated its Santa Rita mine in San Benito County.

The Vermont Asbestos Group mine in Orleans County, Vt., remained the mine with the highest production of asbestos in the United States. Its output decreased slightly from that in 1975. This mine is owned and operated by an employee group, which has been highly successful in its operation.

Arizona production in 1976 was below the 1975 level. The Jaquays Mining Corp., in Gila County, had the only active asbestos mine in the State.

Powhatan Mining Co.'s mine in North Carolina was inactive, but about 878 tons of anthophyllite were mined and shipped from North Carolina in 1976. U.S. asbestos producers and mine sites follow:

State and company[1]	County	Name of mine	Type of asbestos
Arizona: Jaquays Mining Corp	Gila	Chrysotile	Chrysotile.
California:			
Atlas Asbestos Corp	Fresno	Santa Cruz	Do.
Calaveras Asbestos Corp	Calaveras	Copperopolis	Do.
Union Carbide Corp	San Benito	Santa Rita	Do.
Vermont: Vermont Asbestos Group	Orleans	Lowell	Do.

[1]In addition to the States listed, some anthophyllite was mined and shipped from North Carolina, but information on firm and location was not available.

CONSUMPTION AND USES

In a year of partial recovery from the effects of the recession and of the Canadian strike, enduse data for 1976 are difficult to analyze. Asbestos used in asbestos-cement pipe decreased 9%. Further decreases were asbestos cement sheet, 48%; flooring products, 16%; and paper, 53%. Asbestos used in friction products remained about the same, but that used in roofing products increased a surprising 447%, as reported by consumers.

Roofing products accounted for 35% of the asbestos consumed, and was the largest user. Asbestos-cement pipe was next with 19%, followed by flooring products with 16%. When the 3% used in making asbestos-cement sheet is added to the preceding three categories, products used in the construction industry accounted for nearly three-fourths of the asbestos consumed in 1976.

Other major asbestos-using end products were friction materials, 9%; paper, 4%; coatings and compounds, packing and gaskets, and plastics, 3% each; and textiles and insulation (thermal), 1% each.

PRICES

Quoted prices for Quebec asbestos, all chrysotile, were not raised during 1976. The last rise was effective on December 1, 1975. Effective December 1, 1976, British Columbia asbestos chrysotile prices rose 15%.

Prices for Vermont chrysotile asbestos rose 13% on January 1, 1976. Arizona prices rose twice during 1976, the latest on July 1. Quotations, f.o.b. Globe, follow:

Grade	Description	Per short ton
Group 1	Crude	$3,000
Group 2	do	1,800
AAA		1,300
Group 3	Nonferrous filtering and spinning	$750-840
Group 4	Nonferrous plastic and filtering	750-840
Group 7	White shorts	100-200

As of January 1, 1976, Vermont chrysotile asbestos, f.o.b. Morrisville, was priced as follows:

Grade	Description	Per short ton
4T	Fiber	$418
5D through 5R	do	$275-324
6D	Waste	200
7D through 7T	Shorts	83-160
7TF	Floats (shorts)	72
8S	Shorts	54
Hooker No. 1	Packaged in 50-pound woven polyvinyl bags	970
Hooker No. 2	Packaged in 100-pound woven polyvinyl bags	485

Table 3.—U.S. asbestos distribution by end use, grade, and type, 1976

(Short tons)

	Chrysotile								Crocido-lite	Amosite	Antho-phyllite	Total asbestos
	Grades 1 & 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Total chrysotile				
Asbestos-cement pipe	--	600	86,300	26,600	3,100	200	--	116,800	20,300	2,900	--	140,000
Asbestos-cement sheet	--	1,000	2,100	3,600	9,800	5,900	--	22,400	--	200	100	22,700
Flooring products	1,500	1,100	--	6,300	600	104,000	--	113,500	--	--	--	113,500
Roofing products	--	--	--	400	1,900	251,300	--	253,600	--	--	--	253,600
Packing and gaskets	--	1,800	5,900	8,300	700	3,300	--	20,000	100	--	--	20,100
Insulation:												
Thermal	--	--	800	200	1,900	3,600	--	6,500	--	100	--	6,600
Electrical	--	100	--	100	200	1,900	--	2,300	--	--	--	2,300
Friction products	--	2,800	1,500	21,100	6,800	31,000	200	63,400	--	100	300	63,800
Coatings and compounds	--	--	300	300	100	19,200	--	19,900	--	--	--	19,900
Plastics	--	200	2,800	100	1,200	15,400	--	19,700	700	--	1,100	21,500
Textiles	200	6,900	300	--	--	--	--	7,400	--	--	--	7,400
Paper	--	100	1,600	3,300	22,200	3,500	--	30,700	300	--	--	31,000
Other	--	300	800	2,500	4,400	14,700	--	22,700	--	1,200	--	23,900
Total	1,700	14,900	102,400	72,800	52,900	454,000	200	698,900	21,400	4,500	1,500	726,300

Quotations for Canadian (Quebec) chrysotile, f.o.b. mine, as of December 1, 1976, follow:

Grade	Description	Per short ton
Group 1	Crude	Can $3,496
Group 2	do	1,879
Group 3	Spinning fiber	Can $891-1,463
Group 4	Asbestos-cement fiber	492- 829
Group 5	Paper fiber	278- 392
Group 6	Waste, stucco, or plaster	236- 244
Group 7	Refuse or shorts	89- 198

Prices for chrysotile asbestos from British Columbia and Yukon Territory, Canada, effective December 1, 1976, f.o.b. Vancouver, follow:

Grade	Description	Per short ton
	CASSIAR MINE	
C-1	Crude	Can $3,261
AAA	Nonferrous spinning fiber	2,093
AA	do	1,664
A	do	1,267
AC	do	913
AK	Asbestos-cement fiber	651
AS	do	563
AX	do	516
AY	do	362
AZ	do	268
	CLINTON MINE	
CP	Asbestos-cement fiber	Can $611
CT	do	553
CY	do	362
CZ	do	268

African asbestos producers privately negotiate sales, thereby ruling out market quotations. The following tabulation shows the average value per short ton, regardless of grade, of South African imports, calculated from U.S. Department of Commerce data:

Type	1972	1973	1974	1975	1976
Amosite	$187	$188	$228	$395	$461
Crocidolite	211	213	251	427	518
Chrysotile	202	234	282	940	235

The increased demand for and the shortage of all types of asbestos, plus increased mining costs, resulted in price increases in almost all categories. Other price rises were expected early in 1977.

The unit value of 1 ton of Canadian chrysotile has more than doubled in the past 4 years from $Can 122 in 1972 to Can $261 in 1976.

FOREIGN TRADE

No real change occurred from 1975 to 1976 in the value of exports of asbestos products manufactured in the United States. The number of articles exported increased slightly.

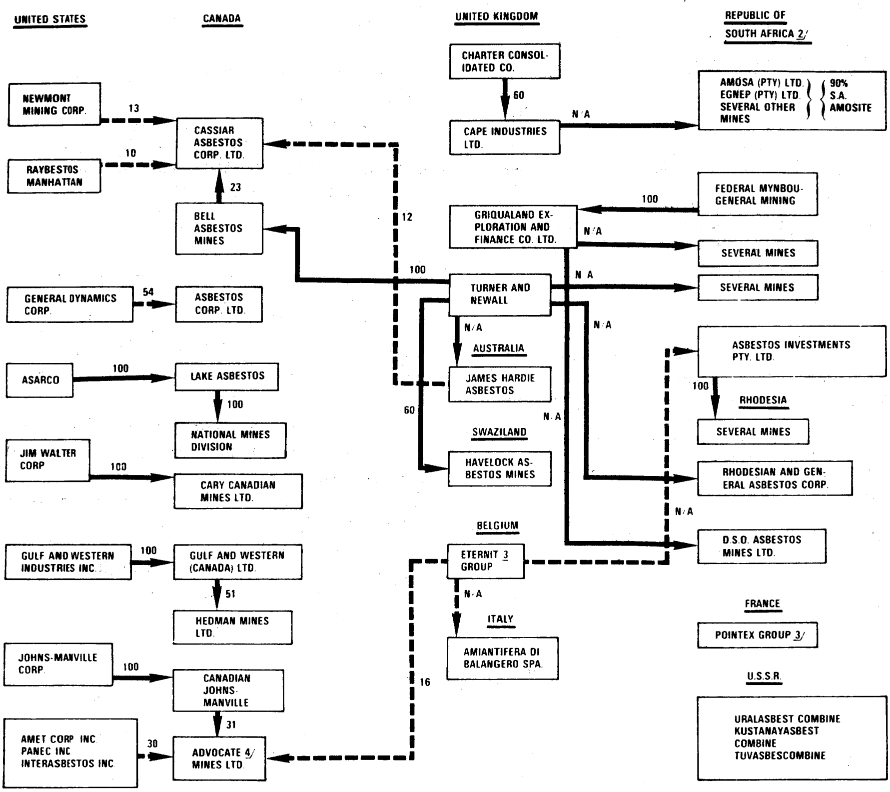
Major groupings of exported products and their share of the total value were textiles and yarns, 22%; friction products, 18%; packing and gaskets, 16%; asbestos-cement products, 14%; and insulation products, 7% (table 4).

Table 4.—Countries importing U.S. asbestos products in 1976, by type

(Thousand dollars)

	Canada	Mexico	Germany, West	United Kingdom	Australia	Other	Total
Friction products	9,382	138	441	73	342	2,820	13,196
Packing and gaskets	2,907	403	304	128	310	7,278	11,330
Asbestos-cement products	2,866	66	275	142	29	6,495	9,873
Textiles and yarn	3,897	4,084	459	344	987	6,213	15,984
Insulation products	1,059	126	37	67	36	3,494	4,819
Other	2,968	1,501	1,633	1,525	193	9,894	17,714
Total	23,079	6,318	3,149	2,279	1,897	36,194	72,916

MAJOR INTERNATIONAL ASBESTOS MINING GROUPS1/



KEY: MAJOR GROUP — 100 COMPANY (MAJOR SHAREHOLDER AND PERCENTAGE); - - 10 COMPANY (MINOR SHAREHOLDER AND PERCENTAGE)

N/A NOT AVAILABLE.

1/ MOST MAJOR GROUPS HAVE MANUFACTURING INTERESTS.
2/ PRODUCTION BREAKDOWN (APPROXIMATE); CROCIDOLITE 50%, AMOSITE 30%, CHRYSOTILE 20%.
3/ PRIMARILY HAVE INTERNATIONAL MANUFACTURING INTERESTS.
4/ OTHER SHAREHOLDERS INCLUDE AMET CORP INC., 16%, PANAC INC., 7%, INTERASBESTOS INC., 7% -- ALL U.S. COMPANIES

SOURCE: MINERAL DEVELOPMENT SECTOR, DEPARTMENT OF ENERGY, MINES AND RESOURCES, OTTAWA, CANADA.

Figure 1.—Major international asbestos mining groups.

In 1976, 52% of the cost of imported asbestos was recovered by exporting and reexporting fibers and products.

In 1976, the United States imported 91% of its asbestos consumption. This was above the 1975 percentage. Canada provided more than 93% of the imports, the Republic of South Africa provided 3%, the U.S.S.R. provided 2%, and six other countries provided the remainder. Chrysotile, with 96%, dominated the imported types. The dollar value of imported fibers was 28% higher than that in 1975.

The larger international asbestos groups and their affiliations are depicted in figure 1, taken from a recent Canadian Government publication.[2]

[2]Vagt, G. O. Asbestos. MR 155, Mineral Policy Series. Department of Energy, Mines, and Resources, Ottawa, Canada, July 1976, 26 pp.

Table 5.—U.S. exports and reexports of asbestos and asbestos products

Products	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
EXPORTS				
Unmanufactured:				
Crude and spinning and nonspinning fibers ____ short tons	15,173	$6,067	21,470	$7,179
Waste and refuse ____ do	19,748	3,992	24,847	5,461
Total ____ do	34,921	10,059	46,317	12,640
Products:				
Gaskets and packing ____ do	2,643	12,401	2,460	11,330
Brake linings ____ do	4,856	9,374	6,239	11,536
Clutch facings, including linings ____ number	1,359,914	1,598	1,007,551	1,660
Textiles and yarn ____ short tons	5,732	7,284	7,522	7,907
Shingles and clapboard ____ do	14,277	4,649	10,610	3,547
Articles of asbestos cement ____ do	18,952	7,628	15,151	6,326
Protective clothing	NA	810	NA	898
Insulation, heat and sound	NA	5,072	NA	4,819
Manufactures, n.e.c	NA	11,740	NA	12,253
Total	XX	60,556	XX	60,276
REEXPORTS				
Unmanufactured:				
Crude and spinning and nonspinning fibers ____ short tons	1,391	573	606	151
Waste and refuse ____ do	135	35	--	--
Total ____ do	1,526	608	606	151
Products:				
Gaskets and packing ____ do	r1	21	4	19
Brake linings ____ do	127	145	221	251
Clutch facings, including linings ____ number	27,645	16	28,143	23
Textiles and yarn ____ short tons	1	11	--	--
Shingles and clapboard ____ do	--	--	12	3
Articles of asbestos cement	NA	6	--	--
Manufactures, n.e.c	NA	21	--	--
Total	XX	220	XX	296

rRevised. NA Not available. XX Not applicable.

Table 6.—U.S. imports for consumption of asbestos from specified countries, by grade

(Short tons)

Grade	1975 Canada	1975 Southern Rhodesia	1975 Republic of South Africa	1976 Canada	1976 Southern Rhodesia	1976 Republic of South Africa
Chrysotile:						
Crude	71	1,633	940	635	3,451	1,745
Spinning fibers	7,637	382	115	5,872	247	61
All other	495,837	608	1,457	611,068	--	6,557
Crocidolite (blue)	--	--	11,570	--	--	10,177
Amosite	--	--	3,894	20	--	1,554
Total	503,545	2,623	17,976	617,595	3,698	20,094

Table 7.—U.S. imports for consumption of asbestos (unmanufactured), by class and country

Year and country	Crude (including blue fiber)		Textile fiber		All other		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1975								
Belgium-Luxembourg	22	$3	--	--	48	$5	70	$8
Canada	71	9	7,637	$5,772	495,837	91,791	503,545	97,572
Finland	--	--	--	--	329	33	329	33
Gaza Strip	--	--	--	--	152	26	152	26
Italy	--	--	--	--	197	37	197	37
Mexico	--	--	--	--	73	15	73	15
Mozambique	118	16	--	--	--	--	118	16
Rhodesia, Southern	1,633	1,521	382	369	608	380	2,623	2,270
South Africa, Republic of	16,404	7,147	115	100	1,457	459	17,976	7,706
Swaziland	2,756	952	--	--	--	--	2,756	952
U.S.S.R	4,525	921	--	--	5,854	1,361	10,379	2,282
United Kingdom	277	83	--	--	58	11	335	94
Total	25,806	10,652	8,134	6,241	504,613	94,118	538,553	111,011
1976								
Australia	99	46	--	--	--	--	99	46
Canada	655	272	5,872	4,613	611,068	121,977	617,595	126,862
Germany, West	--	--	--	--	1,909	383	1,909	383
Hong Kong	--	--	--	--	2	(1)	2	(1)
Mexico	378	209	--	--	1,091	146	1,469	355
Rhodesia, Southern	3,451	2,099	247	208	--	--	3,698	2,307
South Africa, Republic of	13,476	6,932	61	38	6,557	2,616	20,094	9,586
U.S.S.R	--	--	--	--	12,421	2,324	12,421	2,324
United Kingdom	564	282	--	--	--	--	564	282
Total	18,623	9,840	6,180	4,859	633,048	127,446	657,851	142,145

[1]Less than 1/2 unit.

WORLD REVIEW

An in-depth article in a Canadian mining paper,[3] described activities in world and Canadian asbestos markets in 1976. The strength of the Canadian industry, a long time major supplier to the world market, was demonstrated by its rebound in output from the low level experienced in 1975. A fire, landslide, and strike in 1975, resulted in output being reduced to the levels of 1960 and 1961, thereby tightening an already tight supply situation. Many producing companies had to allocate available supplies to their customers. The article also cited statements of Asbestos Corp., Ltd. officials that indicated the asbestos fiber market remained bouyant. Saturation of the markets in Western Europe and the United States, was compensated for by increased demand in Eastern Europe and Middle East and African countries. The firms' inventories of Groups 4, 5, and 6 fibers were expected to stay at minimum levels and those of Groups 3 and 7 to increase slowly. It was anticipated that any excess in Group 3 spinning fibers would be absorbed by the market in the second half of 1977. Only the market for Group 7 appeared to be weak.

Algeria.—Scheduled for June 1976 startup were three identical asbestos-cement-product plants. These plants, designed and built by Belgian companies, will have a combined capacity of 150,000 tons of finished product. The new markets for asbestos fiber to feed these and similar plants being built throughout Mediterranean Africa and Asia are helping keep demand very strong.

Australia.—Woodsreef mine borrowed $A1.5 million to increase its annual capacity to 105,000 tons. Estimates of reserves at both contiguous ore bodies have been revised upward and the company has discovered a promising new ore body near Baryulgil in northern New South Wales. Exploration continued in that Province. Woodsreef acquired 95% of 10 asbestos claims in Western Australia.

Brazil.—The chrysotile mine at Cana Brava operated by S.A. Mineração de Amianto (SAMA) has a projected 1979 production of 115,000 tons, all for domestic consumption. Reserves were estimated at 3.5 million tons of fiber. In 1976 there were

[3]Northern Miner. V. 62, No. 37, Nov. 5, 1976, p. C-10.

900 employees at the site, which is 160 miles northwest of Brasilia.

Canada.—Canadian asbestos production rebounded sharply from the problems of 1975. Total production in 1976 (all chrysotile) was nearly 47% above that of 1975, but still only 92% of the 1973 record.

Abitibi Asbestos Mining Co.'s deposit in northwestern Quebec is 55% owned by Brinco Ltd. At yearend discussions were underway with ASARCO, Inc., owner of Lake Asbestos of Quebec Ltd., as to ways to finance, operate, and market fibers from the proposed $292 million facility. A 220,000-ton-per-year capacity is proposed.

United Asbestos, Inc. was operating its mine at Midlothian Township in Ontario at yearend after having been closed during the spring by Ontario's environmental authorities.

Canadian Johns-Manville Corp. announced a $77-million capital investment program to improve its Jeffrey mine at Asbestos, Quebec. It is a 5-year program, and initial expenditures will be for acquiring property surrounding the mine, repairs, and new facilities. The mine produces 45% of Canada's asbestos and 15% of the world's production.

A possibly important new find in northern Ontario was announced by Talisman Mines, Ltd. and Shield Development Co., Ltd. The find, in Newtown Township, showed asbestos mineralization over 3 miles long and indicated that some fibers may be 1-1/2 inches long and of spinning quality.

China, People's Republic of.—Export data from China for the 1957-74 period reveal that asbestos is not a major export item, either in quantity or value. In 1974, the year of highest export, only 2,400 short tons worth $0.5 million were exported. A number of textile products from China are available on the world market.

Colombia.—Minera Las Brisas, S. A. announced completion of feasibility studies of its asbestos property in the Antioquia Province. Indications are that the deposit has 9.3 million short tons of ore capable of producing 390,000 tons of chrysotile asbestos. Production at a 20,000-ton annual rate is planned to begin in 1979.

France.—French imports of asbestos in 1975 were less than 80% of those in 1974, with the Canadian strike clearly responsible. In 1974, a typical year, the suppliers of asbestos to France were Canada, with 48% of the market; the U.S.S.R., with 31%; the Republic of South Africa, 11%; and Italy, 10%.

Japan.—The large market in Japan for asbestos also declined significantly in 1975. The 29% drop in imports from 1974 cannot be explained by the Canadian strike alone, because other vendors' sales were also down. In 1974 Australia had 5% of the market, Canada, 39%, the Republic of South Africa, 35%, the U.S.S.R., 18%, the United States, 2%, and other, 1%.

Oman.—The Sultanate of Oman, in announcing newly found mineral deposits in the northern part of the country, included asbestos among the minerals to be developed for use in domestic industry.

South Africa, Republic of.—The Republic of South Africa's asbestos producers enjoyed what that nation's press called "spectacular" pre-tax gains from 1975 sales. World market price increases and the heightened demand brought on by the Canadian strike were the main reasons. Inventories were depleted as exports totaled an estimated 150% of production. Amosite production declined 6%, while local sales and exports increased by 136% and 92%, respectively. Chrysotile production was up 21%, and local sales and exports were up 14% and 57%, respectively. Crocidolite production was also up 6%, but local sales and exports rose 73% and 62%, respectively.

Sudan.—Gulf International (Sudan) and Johns-Manville Corp. were conducting a test drilling program on asbestos deposits in the Ingessana Hills of southeastern Sudan near the crossing of the Ethiopian border by the Blue Nile. Indications were favorable for a 100,000-ton-per-year fiber plant which would cost an estimated $115 million.

Turkey.—Among the minerals announced to be found in Eskisehir Province was 500,000 tons of asbestos.

United Kingdom.—Turner Asbestos Fibers Ltd. ordered 880 short tons of Soviet asbestos to replace some of the declining supply from Cassiar's Clinton Mine in the Canadian Yukon.

U.S.S.R.—A Soviet periodical[4] described the Kiyenbai asbestos deposit on the eastern slope of the southern Urals. Ore in the deposit contains 4% asbestos, and by 1979, it is anticipated that a quarter of a million tons will be produced. Output reportedly will increase to 500,000 tons by 1982. To achieve this ore output some 14 million cubic yards of earth and rock will be moved. A new town, Yasny, has been established and in a few years will attain a population of 50,000.

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[4]Soviet Weekly. V. 13, No. 2, Jan. 10, 1976, pp. 14-32.

Table 8.—Asbestos: World production, by country

(Short tons)

Country[1]	1974	1975	1976[p]
North America:			
Canada (shipments)	[r]1,811,938	1,163,673	1,706,999
Mexico	6	29	1
United States (sold or used by producers)	109,091	98,654	114,842
South America:			
Argentina	988	1,238	1,433
Brazil	68,201	81,547	82,673
Europe:			
Bulgaria	[r]27,558	24,251	22,046
Finland[2]	6,165	3,073	--
Italy	163,251	162,018	181,648
Portugal	198	(3)	--
U.S.S.R.[e]	1,500,000	2,090,000	2,520,000
Yugoslavia	13,500	14,330	14,143
Africa:			
Egypt	312	528	1,208
Mozambique	209	--	--
Rhodesia, Southern[e]	180,000	180,000	180,000
South Africa, Republic of	367,369	391,001	407,679
Swaziland	[r]41,796	[4]45,436	[4]46,128
Asia:			
China, People's Republic of[e]	165,000	165,000	165,000
Cyprus	[r]34,674	39,015	38,050
India	[r]25,653	22,654	24,965
Japan	[r]5,655	5,084	8,491
Korea, Republic of	6,294	4,790	5,249
Taiwan	[r]3,260	1,915	940
Thailand	(3)	(3)	17
Turkey	17,181	17,081	10,557
Oceania: Australia	[r]34,021	52,813	33,841
Total	[r]4,582,320	4,564,130	5,565,910

[e]Estimate. [p]Preliminary. [r]Revised.
[1]In addition to the countries listed, Czechoslovakia, North Korea, and Romania also produce asbestos, but available information is inadequate to make reliable estimates of output levels.
[2]Includes asbestos flour.
[3]Revised to zero.
[4]Exports.

TECHNOLOGY

In 1976, as in previous years, much of the research on asbestos concerned the problems arising from alleged health effects and regulations (both current and proposed) to minimize the hazards. By the July 1, 1976 changeover date to the 2-f/cm^3 level, the asbestos-containing product industry and the domestic-asbestos-producing industry were generally in compliance, but engineering research aimed at further reduction of dust-exposure levels continued.

The NIOSH method of monitoring the workplace and identifying asbestos continued to be a matter of controversy. At least two separate actions took place late in 1976 because of this controversy:

The National Bureau of Standards agreed to determine the asbestos content of a series of talc samples for OSHA, using the NIOSH method (as given in 29 CFR 1910.1001) and OSHA's "Asbestos Fiber in Air" Method (No. P & CAM239, dated Mar. 30, 1976).

The Bureau of Mines has established a Particulate Mineralogy Unit at its College Park, Md., Metallurgy Research Center. In the announcement made November 15, 1976, the Director of the Bureau stated, "Its job is to develop a solid scientific basis for research into particle-related pollution problems and for the process of decision-making by regulatory bodies." A major activity of the Particulate Mineralogy Unit will be characterizing morphological, compositional, and structural distinctions between asbestos and nonasbestos particles. The new unit also will work to develop new and improved methods for positively identifying small particles.

The National Institute of Environmental Health Science's animal-feeding study to determine if ingested asbestos is carcinogenic was proceeding on schedule, but no results were reported in 1976.

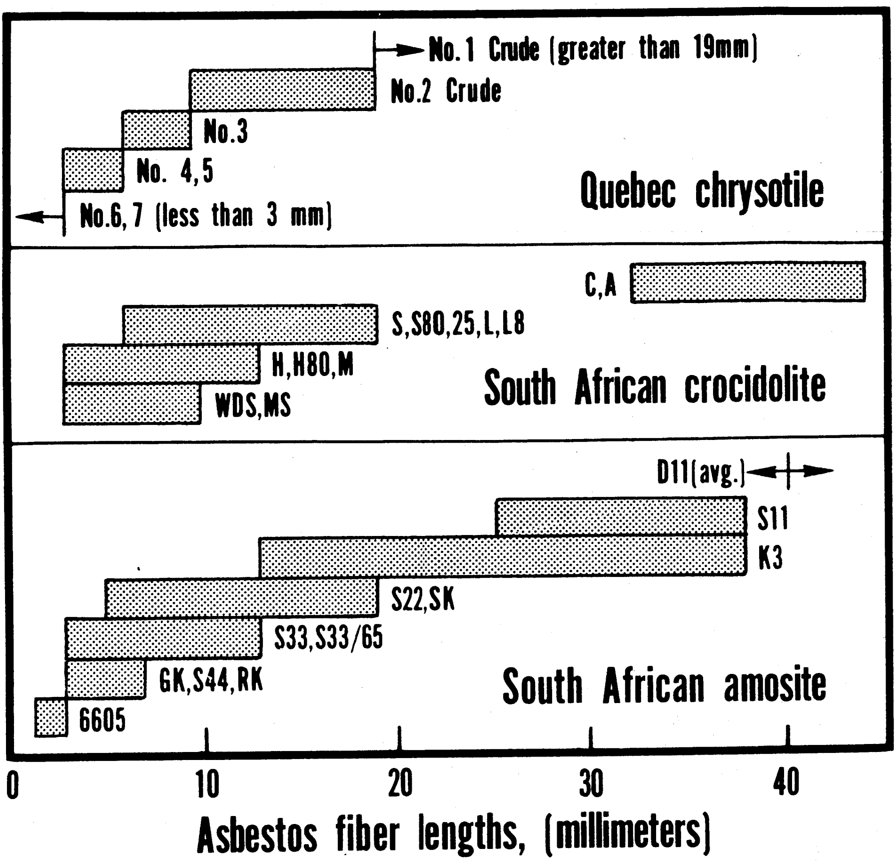

Figure 2.—Asbestos fiber lengths (millimeters).

The International Agency for Research on Cancer (IARC) of Lyon, France, initiated a three-pronged study into carcinogenic activity of man-made mineral fibers used as asbestos substitutes. The European glass-fiber and textile industries asked IARC to carry out epidemiological studies in 70 factories and 15 countries, laboratory studies on animals, and fiber-dust measurements in factories using these materials.

The search for asbestos substitutes continued. One product now available commercially in the United States and Europe that could affect the future of the asbestos industry is glass-reinforced cement. The glass used is a high-zirconia, alkali-resistant fiber developed by the United Kingdom's Building Research Station. However, several drawbacks to the product were reported: The glass fibers have inferior drainage characteristics; they require a costly spray-suction forming process; the strength gradually fails with time; and the fibers currently cost about four times as much as the equivalent asbestos.[5]

Asbestos shortages and projected demands indicated serious depletion of reserves by the end of the century. Accelerated research seems needed to find substitute fibers that will have at least some of the desirable asbestos characteristics of strength, chemical inertness, heat resistance, and economy in the same fiber.

Figure 2 provides the metric equivalent of fiber descriptions in the English system or Quebec Standard Classification.

[5]Industrial Minerals (London). Asbestos Alternatives, No. 109, October 1976, pp. 45-47.

Barite

By Stanley K. Haines[1]

Domestic production of barite decreased 6% from 1.32 million tons in 1975 to 1.23 million tons in 1976. Nevada continued as the leading producing State with 73% of the total production of primary barite; however, production in Nevada declined 5% below 1975 levels. Imports of crude barite increased 43% to 905,000 tons. All major end-uses of ground barite increased compared with 1975 levels, for a total consumption of 2.2 million tons. The oil- and gas-well drilling industries were the leading consumers of ground domestic and imported barite with 90% of the total.

Table 1.—Salient barite and barium-chemical statistics

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Barite (primary):					
Sold or used by producers	906	1,104	1,106	r1,318	1,234
Value	$14,883	$16,688	$16,822	r$21,200	$28,689
Imports for consumption	624	716	729	634	905
Value	$5,648	$7,596	$8,680	$8,541	$17,677
Crushed and ground, sold or used	1,461	1,571	1,637	1,807	2,192
Value	$45,590	$54,473	$64,394	$73,075	$93,283
Barium chemicals, sold by producers	66	62	56	43	52
Value	$13,869	$13,899	$15,751	$15,556	$12,389
World: Production	4,360	4,945	r5,109	r5,358	5,457

rRevised.

Table 2.—Barite sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1975		1976	
	Quantity	Value	Quantity	Value
Alaska	2	30	W	W
California	1	W	W	W
Missouri	171	3,989	124	3,860
Nevada	r947	r11,533	900	18,379
Other States[1]	198	5,647	210	6,450
Total[2]	r1,318	r21,200	1,234	28,689

rRevised. W Withheld to avoid disclosing individual company confidential data, included with "Other States."
[1]Including Arkansas, Georgia, Idaho, Illinois, Montana, Tennessee, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

DOMESTIC PRODUCTION

Producers sold or used 1,234,000 tons of primary barite in 1976. Primary barite is the first marketable product and includes crude or run-of-mine barite, flotation con-

[1]Physical scientist, Division of Nonmetallic Minerals.

centrates, and other beneficiated material such as washer, jig, or magnetic separation concentrates.

Barite was produced at 36 mines: 17 in Nevada, 10 in Missouri, 3 in Arkansas, 2 in Georgia, and 1 each in Idaho, Illinois, Montana, and Tennessee. Nevada remained the leading producing State with 73% of the total quantity and 64% of the total value. The other producing States were, in descending order of production, Missouri, Arkansas, Georgia, Tennessee, Montana, Idaho, and Illinois.

Run-of-mine barite sold or used by producers represented 48% of total production, other beneficiated material, 44%; and flotation concentrate, 8%.

The leading producers of domestic barite for use in well drilling were (in alphabetical order) Baroid Div., NL Industries, Inc., with mines in Arkansas, Missouri, and Nevada; Dresser Minerals Div., Dresser Industries, Inc., with mines in Missouri and Nevada; and Minerals Div., Milchem, Inc., with mines in Missouri and Nevada.

Barite for chemical, glass, and filler uses was sold by C. R. Wood Co., Inc.; Dresser Minerals Div., Dresser Industries, Inc.; Industrial Chemical Div., FMC Corp.; IMCO Services Div., Halliburton Co.; Milwhite Co., Inc.; New Riverside Ochre Co.; De Lore Products, Industrial Chemicals Div., NL Industries, Inc.; Paga Mining Co.; Minerals, Pigments, and Metals Div., Pfizer, Inc.; and Standard Slag, Inc.

Imported and/or domestic barite was ground at 44 plants in 12 States. Texas with nine plants and Louisiana with seven had the heaviest concentration of grinding plants, due to the availability of port facilities for imported barite and the close proximity to areas of high drilling activity. Other States with grinding plants were Missouri, with six operations; Nevada and Utah, five each; California, four; Arkansas and Georgia, two each; and Alaska, Illinois, Montana, and Tennessee, one each.

CONSUMPTION AND USES

Barite for use as a weighting agent in oil- and gas-well drilling fluids represented the dominant end-use of crushed and ground barite in 1976. Total quantity consumed for this use increased 21% to 1,986,000 tons in 1976 owing to increased drilling activity; total footage drilled increased from 178.5 million feet in 1975 to 181.7 million feet. Barite for use in the manufacture of barium chemicals and paint increased 9% and 43%, respectively. Other uses declined 11%, and included filler in rubber and plastics; flux, oxidizer, and decolorizer in glass manufacture; and miscellaneous uses, including ballast for ships, heavy concrete aggregate, and unspecified industrial uses.

The data in table 3 are mainly for ground barite, but they also include the relatively small quantity of crushed barite used primarily in the barium-chemical industry.

Barite is the principal raw material used in the production of barium chemicals. Producers of barium chemicals in 1976 were J. T. Baker Chemical Co., Phillipsburg, N. J.; Chemical Products Corp., Cartersville, Ga.; Industrial Chemical Div., FMC Corp., Modesto, Calif.; Mallinckrodt, Inc., St. Louis, Mo.; and Chemical Div., Sherwin-Williams

Table 3.—Crushed and ground barite sold, by use[1]

Use[2]	1975		1976	
	Short tons	Percent of total	Short tons	Percent of total
Barium chemicals[3]	71,788	4	78,354	4
Filler or extender:				
Paint	34,817	2	49,731	2
Rubber	W	--	W	--
Other filler	W	--	14,358	1
Well drilling	1,638,370	90	1,985,966	90
Other uses	85,221	4	75,908	3
Total	1,830,196	100	2,204,317	100

W Withheld to avoid disclosing individual company confidential data, included with "Other uses."
[1]Includes imported barite.
[2]Uses reported by producers of ground and crushed barite, except for barium chemicals.
[3]Quantities reported by consumers.

Co., Coffeyville, Kans. Sherwin-Williams also produced lithopone.

IMCO Services Div., Halliburton, Inc. finished construction of a jig, table, and flotation plant at Mountain Springs, Nev. The capacity of the facility is about 150,000 tons per year. IMCO also installed a second mill at Battle Mountain, Nev., and a jig plant at its Norris (Clipper) mine in Lander County, Nev.

The Mining and Minerals Div. of Chromalloy has begun construction of a heavy-media concentrating plant at Castle Island, Alaska, to produce barite for the Alaska drilling market. Chromalloy has also installed a jig plant near Marion, Ky.

Milchem, Inc., began exploratory drilling and quality testing on the Fancy Hill barite property in Montgomery County, Ark.[2]

Sales of barium carbonate increased 25% from 28,018 short tons in 1975 to 34,991 short tons in 1976. Total production increased 37%. Barium carbonate is used in the manufacture of television picture tubes (for screen control), in brick and tile, in barium-ferrite manufacture, and for many other purposes.

Table 4.—Barium chemicals produced and sold by producers in the United States in 1976[1]

Barium chemical	Plants	Production (short tons)	Sold by producers	
			Quantity (short tons)	Value
Barium carbonate	4	35,488	34,991	$4,857,355
Barium chloride	3	W	W	W
Barium hydroxide	3	W	W	W
Black ash	2	W	W	W
Blanc fixe	1	W	W	W
Other barium chemicals	4	24,825	17,107	7,531,596
Total	[2]6	60,313	52,098	12,388,951

W Withheld to avoid disclosing individual company confidential data; included with "Other barium chemicals."
[1]Only data reported by barium-chemical plants that consume barite are included.
[2]A plant producing more than one product is counted only once.

PRICES

Prices for chemical, filler, and glass grades of barite increased while those for drilling-mud grade remained constant, according to the Engineering and Mining Journal. The prices listed in table 5 are from trade publications; they serve as a general guide but do not necessarily reflect actual transactions.

The average value per ton of crude barite was $23.25, a 44% increase over the 1975 value of $16.08. The average value per ton of crushed and ground barite increased to $42.56 in 1976, from $40.44 in 1975.

[2]Stevens, R. M., Barite. Mining Engineering. V. 29, No. 3, March 1977, pp. 53-54.

Table 5.—Barite price quotations in 1976

Item	Price per short ton
Barite:[1]	
Chemical, filler, glass grades, f.o.b. shipping point, carload lots:	
Handpicked, 95% $BaSO_4$, not over 1% Fe	$42.50- $50.00
Magnetic or flotation, 96% $BaSO_4$, not over 0.5% Fe	60.00- 70.00
Water-ground, 99.5% $BaSO_4$, 325 mesh, 50-pound bags	60.00- 80.00
Drilling-mud grade:	
Ground, 83%-93% $BaSO_4$, 3%-12% Fe, specific gravity 4.20-4.30, f.o.b. shipping point, carload lots	71.00- 78.00
Crude, imported, specific gravity 4.20-4.30, c.i.f. gulf ports	19.00- 28.00
Barium chemicals:[2]	
Barium carbonate:	
Precip., bulk, c.l., freight equalized (ton)	250.00- 275.00
Electronics grade, bags, same basis	255.00
Barium chloride:	
Purified Fe cryst., 400 pound drums, at works	1.24
Technical cryst., bags, c.l. works (ton)	300.00
Anhydrous, bags, c.l., same basis (ton)	400.00
Barium sulfate:	
USP X-ray diagnosis grade, powder, 250 pound drums, 1,250 pound lots	.25
Barium sulfide (black ash) drums, c.l., works (ton)	115.00- 150.00

[1]Engineering and Mining Journal. V. 177, No. 12, December 1976, pp. 46-47.
[2]Chemical Marketing Reporter. V. 210, No. 26, Dec. 27, 1976, p. 32.

FOREIGN TRADE

Exports of barite declined 28% from 57,386 tons in 1975 to 41,063 tons in 1976. Canada replaced Japan as the leading recipient of these exports. Barite, primarily ground material, was shipped principally from the following customs districts: Seat-

Table 6.—U.S. exports of natural barium sulfate and carbonate

Country	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Angola	2,055	$145	--	--
Argentina	20	4	97	$4
Australia	362	19	20	4
Brazil	3,162	196	287	21
Canada	8,768	600	26,382	1,875
Colombia	78	3	212	9
Costa Rica	48	2	34	1
El Salvador	83	9	123	17
Germany, West	89	4	57	3
Ghana	479	37	--	--
Guatemala	1,586	130	9,064	543
Indonesia	61	3	--	--
Israel	--	--	600	53
Jamaica	--	--	39	2
Japan	36,316	165	49	24
Korea, Republic of	27	1	--	--
Lebanon	93	4	--	--
Mauritius	1,027	72	--	--
Mexico	54	6	704	32
Netherlands	101	4	14	1
New Zealand	335	92	--	--
Nicaragua	208	15	--	--
Panama	30	1	--	--
Paraguay	--	--	351	27
Peru	--	--	5	1
Philippines	129	10	174	11
Singapore	20	3	--	--
South Africa, Republic of	287	23	130	6
Surinam	1,102	85	--	--
Switzerland	--	--	44	2
Taiwan	528	70	52	2
Trinidad and Tobago	--	--	2,500	220
United Arab Emirates	150	139	--	--
United Kingdom	59	3	--	--
Venezuela	129	23	125	13
Total	57,386	1,868	41,063	2,871

tle, Wash. (37%), Houston, Tex. (23%), New Orleans, La. (15%), Detroit, Mich. (8%), and Great Falls, Mont. (6%).

Imports of crude barite increased 43% to 904,500 short tons valued at $17,677,000 in 1976. This increase resulted from a combination of a decline in domestic production and an increase in drilling activity. The principal source countries were Peru, Ireland, and Turkey. Declared values per short ton of crude barite for these countries averaged as follows: Peru, $15.46; Ireland, $11.70; and Turkey, $28.00.

Most of the crude barite imported was drilling-mud grade and entered the United States through the following customs districts: New Orleans, La. (41%), Houston, Tex. (21%), Laredo, Tex. (15%), Port Authur, Tex. (12%), Galveston, Tex. (11%), and a small quantity through El Paso, Tex., and New York, N.Y.

Imports of ground barite decreased 66% to 13,288 tons valued at $151,687. Mexico, the leading source country, reportedly exported 6 short tons of crude witherite (natural barium carbonate) to the United States, and West Germany reportedly exported 278 short tons of ground witherite to the United States. These data are open to question since there has been no reported production of witherite since the Settlingstone mine in northern England was closed in 1969. A recent inquiry by the Bureau of Mines to officials in West Germany brought a reply that stated that there was no production of natural witherite in 1976. Imports into West Germany of crude witherite of unknown origin were 7,718 short tons, but there was no breakdown between natural and manmade. The imports of the United States from West Germany were probably precipitated (manmade) barium carbonate.

Imports of barium chemicals increased 55% compared with those in 1975. The following categories showed significant increases in quantity imported: Lithopone (360%), precipitated barium carbonate (255%), barium chloride (186%), and blanc fixe (46%). Imports of barium hydroxide, barium nitrate, and other barium compounds declined.

Table 7.—U.S. exports of lithopone

Year	Quantity (short tons)	Value (thousands)
1974	1,185	$967
1975	1,833	1,060
1976	779	937

Table 8.—U.S. imports for consumption of barite, by country

(Thousand short tons and thousand dollars)

Country	1975		1976	
	Quantity	Value	Quantity	Value
Crude barite:				
Canada	47	541	62	861
Chile	--	--	12	283
Denmark	11	185	--	--
France	--	--	27	1,079
Germany, East	9	159	(1)	1
Germany, West	--	--	4	77
Greece	47	839	17	385
Ireland	107	1,197	199	2,328
Mexico	104	1,310	106	1,605
Morocco	47	1,286	101	3,078
Mozambique	--	--	18	561
Peru	261	3,022	210	3,246
Turkey	--	--	149	4,173
United Arab Emirates	1	2	--	--
Total	634	8,541	905	17,677
Ground barite:				
Canada	3	307	(1)	7
Colombia	--	--	(1)	2
Germany, West	--	--	(1)	(1)
Mexico	35	404	13	143
Peru	(1)	12	--	--
Total	38	723	13	152

[1]Less than 1/2 unit.

Table 9.—U.S. imports for consumption of barium chemicals

Year	Lithopone		Blanc fixe (precipitated barium sulfate)		Barium chloride		Barium hydroxide	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	262	$139	8,843	$2,273	13,455	$3,545	10,072	$4,173
1975	15	6	5,443	2,047	1,199	358	2,595	1,492
1976	69	25	7,971	2,643	3,425	690	2,422	1,090

Year	Barium nitrate		Barium carbonate precipitated		Other barium compounds	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	455	$151	8,719	$1,723	1,577	$1,029
1975	593	233	681	111	411	196
1976	520	122	2,420	423	86	102

Table 10.—U.S. imports for consumption of crude, unground, and crushed or ground witherite

Year	Crude, unground		Crushed or ground	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	3	$1	3,432	$709
1975	1	(1)	84	44
1976	6	5	278	56

[1]Less than 1/2 unit.

WORLD REVIEW

World barite production for 1976 was estimated to be 5.5 million short tons; United States production was 23% of the world total.

Canada.—A final feasibility study concerning the TEA barite deposit in the Yukon Territory was slated for completion in July 1976. The deposit was discovered by Welcome North Mines in 1975. Initial plans call for production of 15,000 to 20,000 tons per year of drilling-mud grade barite. The deposit is a high-quality, bedded barite for which only minimal processing will be necessary before grinding. Reserves are estimated to be more than 1 million tons. The principal market will be the oil- and gas-well drilling operations in the Arctic.[3]

Mexico.—Producers of drilling-mud grade barite have indicated displeasure with the Government's ceiling on prices that the State-owned petroleum company may pay for the barite. The current price is $12 per ton in Mexico. The producers believe that they have the capacity to supply both the domestic and export markets if the price were allowed to rise. If there is no change in the pricing structure, producers have threatened to suspend operations.[4]

Pakistan.—On September 27, 1976, the first shipment of barite moved from the Goonga deposits near Khuzdar to the Meyel oilfields. Reserves at these deposits are estimated at 1.2 million tons. First-year production is expected to be about 15,000 tons, with an expected increase to 60,000 tons in 5 years. The barite will be used for local drilling and export.[5]

Other Countries.—Atlantic Products Corp., a Colombian barite producer, was purchased by Baroid Div., NL Industries, Inc. Construction of or modification to beneficiation and grinding plants were reported in Algeria, the Netherlands, Mexico, and Saudi Arabia. Milchem, Inc. is planning to reopen a barite mine at Clontakilty, County Corke, Ireland. The mine which was closed in 1922, is expected to begin production in 1978.

[3]Engineering and Mining Journal. New Yukon Mine Will Produce Barite to Supply Artic Needs. V. 177, No. 4, April 1976, p. 139.

[4]Industrial Minerals (London). No. 109, October 1976, p. 13.

[5]Progress (Pakistan). Barytes from Khuzdar to be Used at Meyal. V. 21, No. 3, October 1976, p. 1.

Table 11.—Barite: World production, by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
North America:			
Canada	86	90	[e]72
Mexico	300	331	298
United States[2]	1,106	1,318	1,234
South America:			
Argentina	[r]40	43	[e]45
Brazil	67	59	[e]60
Chile	5	7	19
Colombia	3	3	3
Peru	394	[e]255	365
Europe:			
Austria	(3)	(3)	(3)
Czechoslovakia[e]	8	8	8
France	116	101	165
Germany, East[e]	34	34	34
Germany, West	329	273	289
Greece[4]	[r]94	115	67
Ireland	[r]379	325	356
Italy	198	235	197
Poland	57	59	89
Portugal	2	3	(3)
Romania[e]	128	128	128
Spain	115	85	[e]85
U.S.S.R.[e]	360	380	440
United Kingdom	55	56	[e]55
Yugoslavia	55	67	[e]67
Africa:			
Algeria	58	75	83
Egypt	(3)	1	(3)
Kenya	(3)	(3)	[e](3)
Morocco	103	132	144
South Africa, Republic of	2	1	2
Swaziland	(3)	(3)	[e](3)
Tunisia	19	7	26
Asia:			
Afghanistan[5]	[r]11	6	6
Burma	[6]17	17	15
China, People's Republic of[e]	220	275	300
India	[r]158	193	205
Iran[5]	[e r]130	161	[e]190
Japan	42	41	59
Korea, North[e]	[r]130	[r]130	130
Korea, Republic of	1	2	5
Malaysia	--	1	7
Pakistan	5	5	6
Philippines	--	4	4
Thailand	221	285	167
Turkey	53	21	[e]22
Oceania: Australia	8	26	[e]10
Total	[r]5,109	5,358	5,457

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed Bulgaria and Southern Rhodesia also produce barite, but available information is inadequate to make reliable estimates of output levels.

[2]Sold or used by producers.

[3]Less than 1/2 unit.

[4]Barite concentrates.

[5]Year beginning March 21 of that stated.

[6]Year beginning April 1 of that stated.

Bauxite and Alumina

By Horace F. Kurtz[1]

World bauxite and alumina production increased in 1976 but remained below the record high levels set in 1974. Both the decline in production in 1975 and the partial recovery in 1976 resulted from recession-caused changes in demand for aluminum, the principal end use of bauxite and alumina.

World bauxite production increased 2% to 76.3 million long tons in 1976. Output of alumina, the intermediate product between bauxite and aluminum production, rose 3% to about 29.6 million short tons. Australia replaced the United States as the world's leading producer of alumina.

U.S. bauxite and alumina production increased 11% and 13%, respectively. Imports provided about 36% of the new supply of alumina and 87% of the bauxite used by domestic alumina producers.

Legislation and Government Programs.—The Federal Preparedness Agency, General Services Administration, on October 1 proposed new Government stockpile goals which would greatly reduce existing stockpiles of metal-grade bauxite and establish a new stockpile of about 11.5 million short tons of alumina. Stocks of refractory-grade bauxite would be increased to over 2 million long calcined tons.

Table 1.—Salient bauxite statistics

(Thousand long tons and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Production, crude ore (dry equivalent)	1,812	1,879	1,949	1,772	1,958
Value	$23,238	$26,635	$25,663	$25,083	$26,645
Exports (as shipped)	29	12	16	19	15
Imports for consumption [1]	r12,601	r13,403	r14,976	r11,529	12,548
Consumption (dry equivalent)	15,375	16,650	16,904	r12,388	13,817
World: Production	63,921	69,244	r78,362	r74,503	76,337

rRevised.
[1]Excludes calcined bauxite. Includes bauxite imported into the Virgin Islands.

DOMESTIC PRODUCTION

The production of bauxite in the United States increased 11% to 1.96 million long tons (dry equivalent) in 1976. Production in both Arkansas and Georgia increased, but output in Alabama declined. Arkansas produced 85% of the total. All of the bauxite mines were open pit operations except for the Mars Hill underground mine of Reynolds Mining Corp. in Saline County, Ark.

In Arkansas, Aluminum Co. of America (Alcoa), American Cyanamid Co., and Reynolds produced bauxite in Saline County. Reynolds also mined in Pulaski County. Both Alcoa and Reynolds delivered crude bauxite to their own alumina plants nearby. Plants producing calcined bauxite or activated bauxite were operated by American Cyanamid, Porocel Corp., and Stauffer Chemical Co.

In Alabama, bauxite was mined in the Eufaula district, Barbour and Henry Counties, by Abbeville Lime Co., A. P. Green Refractories Co., Harbison-Walker Refractories Co. (Division of Dresser Indus-

[1]Industry economist, Division of Nonferrous Metals.

tries, Inc.), and Wilson-Snead Mining Co. Drying or calcining plants were operated by A. P. Green, Harbison-Walker, and Wilson-Snead.

American Cyanamid and Mullite Co. of America mined bauxite in Sumter County, Ga., and operated processing plants at Andersonville, Ga.

Production at alumina plants, which had been reduced in 1975 because of lower demand for aluminum, was partially restored in 1976. Production of alumina and aluminum oxide products (excluding aluminates) at the eight alumina plants in the United States and the one plant in the U.S. Virgin Islands increased 13% to an estimated 6.6 million short tons (6.4 million tons calcined alumina equivalent). The total production included an estimated 5.9 million tons of calcined alumina, 600,000 tons of commercial alumina trihydrate, and 100,000 tons of tabular, activated, and other alumina.

Alumina shipments by producers totaled 6.6 million tons (6.4 million tons calcined equivalent) and were valued at $880 million. Calcined alumina shipments to primary aluminum plants totaled 5.7 million tons, or 89% of the calcined equivalent of total shipments. The chemical industry, including producers of aluminum fluoride fluxes for aluminum plants, received over half of the remaining tonnage, largely as hydrate. Other shipments of alumina went mainly to producers of abrasives, ceramics, and refractories.

Table 2.—Mine production of bauxite and shipments from mines and processing plants to consumers in the United States

(Thousand long tons and thousand dollars)

State and year	Mine production			Shipments from mines and processing plants to consumers		
	Crude	Dry equivalent	Value[1]	As shipped	Dry equivalent	Value[1]
Alabama and Georgia:						
1972	227	178	2,228	131	173	4,533
1973	247	193	2,751	171	225	5,731
1974	272	218	2,066	154	211	6,124
1975	302	229	2,127	175	236	5,622
1976	369	291	2,165	135	214	8,861
Arkansas:						
1972	1,973	1,634	21,010	2,127	1,844	25,085
1973	2,040	1,686	23,884	2,076	1,780	26,708
1974	2,098	1,731	23,597	2,130	1,810	26,737
1975	1,862	1,543	22,956	1,883	1,599	25,486
1976	2,013	1,667	24,481	2,035	1,728	27,580
Total United States:[2]						
1972	2,200	1,812	23,238	2,258	2,017	29,618
1973	2,287	1,879	26,635	2,246	2,005	32,439
1974	2,370	1,949	25,663	2,284	2,021	32,862
1975	2,164	1,772	25,083	2,058	1,836	31,108
1976	2,382	1,958	26,645	2,171	1,941	36,441

[1]Computed from values assigned by producers and from estimates of the Bureau of Mines.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—Recovery of dried, calcined, and activated bauxite in the United States

(Thousand long tons)

Year	Crude ore treated	Total processed bauxite recovered[1]	
		As re-covered	Dry equiv-alent
1972	399	210	319
1973	338	169	287
1974	348	177	279
1975	355	179	282
1976	360	172	284

[1]Dried, calcined, and activated bauxite.

Table 4.—Percent of domestic bauxite shipments, by silica content

SiO_2 (Percent)	1972	1973	1974	1975	1976
Less than 8	6	6	2	4	6
From 8 to 15	64	61	72	62	50
More than 15	30	33	26	34	44

Table 5.—Production and shipments of alumina in the United States

(Thousand short tons)

Year	Calcined alumina	Other alumina [1]	Total: As produced or shipped [2]	Total: Calcined equivalent
Production:[3]				
1972	6,235	741	6,976	6,739
1973	6,834	734	7,568	7,344
1974	7,059	753	7,812	7,589
1975	5,223	624	5,847	5,660
1976 [e]	5,900	700	6,600	6,400
Shipments:				
1972	6,222	745	6,968	6,730
1973	6,822	738	7,561	7,335
1974	7,051	745	7,796	7,575
1975	5,232	628	5,860	5,671
1976 [e]	5,900	700	6,600	6,400

[e]Estimate.
[1]Trihydrate, activated, tabular and other aluminas. Excludes calcium and sodium aluminates.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes only the end product if one type of alumina was produced and used to make another type of alumina.

Table 6.—Capacities of domestic alumina plants, December 31, 1976[1]

(Thousand short tons per year)

Company and plant	Capacity
Aluminum Co. of America:	
Bauxite, Ark	375
Mobile, Ala	990
Point Comfort, Tex	1,335
Total	2,700
Martin Marietta Aluminum, Inc.: St. Croix, V.I	455
Kaiser Aluminum & Chemical Corp.:	
Baton Rouge, La	1,025
Gramercy, La	800
Total	1,825
Ormet Corp.: Burnside, La	600
Reynolds Metals Co.:	
Hurricane Creek, Ark	840
Corpus Christi, Tex	1,385
Total	2,225
Grand total	7,805

[1]Capacity may vary depending upon the bauxite used.

CONSUMPTION AND USES

Bauxite consumption in the United States (including the U.S. Virgin Islands) gained 12% or about 1.4 million long dry tons. Despite the increase, consumption remained below the annual rates of 1966-74. About 87% of the bauxite consumed during 1976 came from foreign countries.

Bauxite consumed in the production of alumina increased 12% and comprised 93% of the total bauxite consumed. An estimated average of 2.02 long tons (dry basis) of bauxite was used to produce 1 short ton (calcined basis) of alumina. The two alumina plants in Arkansas used mainly bauxite mined in Arkansas, and the other seven alumina plants used only imported ore.

Bauxite use by the refractory industry declined 2% to 401,000 tons (dry weight basis). Nearly all of this bauxite was used in the calcined form, which weighs about 65%

of the dry equivalent weight. Imports comprised 78% of the bauxite used in refractories. Refractory producers reported receipts of about 90,000 tons (dry basis) of domestic bauxite and 430,000 tons of imported ore. An estimated 93% of the foreign bauxite came from Guyana, and most of the remainder came from Surinam.

Five companies consumed calcined bauxite in the manufacture of artificial abrasives. Over half of the bauxite received by these companies came from Surinam. Australia and the People's Republic of China provided most of the remainder. Total consumption by the abrasives industry increased 35% in 1976. The Carborundum Co. announced the installation of a new furnace to produce aluminum oxide abrasive material at its facilities in Niagara Falls, Canada.[2] Data on consumption by the abrasives industry include bauxite fused and crushed in Canada because much of the fused product is made into abrasive wheels and coated products in the United States. About 10% to 15% of this material is used for nonabrasive applications, principally refractories.

Bauxite consumption in the chemicals industry decreased 17% from 221,000 tons (revised) in 1975 to 184,000 tons in 1976. Guyana and the United States were the principal sources of bauxite for this industry. The production of commercial aluminum sulfate in the United States, according to the Bureau of the Census,[3] decreased from 1.16 million short tons (revised) in 1975 to 1.09 million tons in 1976.

Other consumers of bauxite, in descending order of magnitude, included the cement, oil and gas, and steel and ferroalloys industries, and municipal waterworks.

Thirty-one U.S. primary aluminum plants consumed 8,117,000 short tons of calcined alumina, 8% more than the 7,508,000 tons consumed in 1975. Alumina consumption data for other uses were not available. A significant quantity was used to make aluminum fluoride and synthetic cryolite, which is also used in the production of primary aluminum.

[2]Larsen, R. New Carborundum Furnace To Hike Aluminum Oxide Output, Cut Costs. Am. Metal Market, v. 83, No. 126, June 28, 1976, p. 11.

[3]Bureau of the Census, U.S. Dept. of Commerce. Current Industrial Reports, Inorganic Chemicals, Summary for 1976. M28A(76)-13, May 1977, p. 2.

Table 7.—Bauxite consumed in the United States by industry

(Thousand long tons, dry equivalent)

Year and industry	Domestic	Foreign	Total[1]
1975:			
Alumina	1,531	9,966	11,497
Abrasive[2]	--	193	193
Chemical	r 3106	3182	r221
Refractory	94	316	410
Other	W	W	67
Total[1] [2]	r1,731	10,657	r12,388
1976:			
Alumina	1,652	11,254	12,905
Abrasive[2]	--	260	260
Chemical	367	3184	184
Refractory	87	314	401
Other	W	W	67
Total[1] [2]	1,806	12,012	13,817

rRevised. W Withheld to avoid disclosing individual company confidential data; included with "Chemical."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes consumption by Canadian abrasive industry.
[3]Includes other uses.

Table 8.—Crude and processed bauxite consumed in the United States

(Thousand long tons, dry equivalent)

Type	Domestic origin	Foreign origin	Total[1]
1975:			
Crude and dried	1,546	10,142	11,688
Calcined and activated	r185	515	r700
Total	r1,731	10,657	r12,388
1976:			
Crude and dried	1,669	11,433	13,102
Calcined and activated	137	578	715
Total	1,806	112,012	13,817

rRevised.
[1]Data may not add to totals shown because of independent rounding.

Table 9.—Production and shipments of selected aluminum salts in the United States, in 1975

(Thousand short tons and thousand dollars)

Item	Number of producing plants	Production	Total shipments including interplant transfers: Quantity	Total shipments including interplant transfers: Value
Aluminum sulfate:				
Commercial (17% Al_2O_3)	68	1,158	1,115	73,087
Municipal (17% Al_2O_3)	3	5	XX	XX
Iron-free (17% Al_2O_3)	18	252	251	7,938
Aluminum chloride:				
Liquid (32°Bé)	5	W	W	W
Crystal (32°Bé)				
Anhydrous (100% $AlCl_3$)	5	27	27	18,245
Aluminum fluoride, technical	4	130	127	46,003
Aluminum hydroxide, trihydrate (100% $Al_2O_3 \cdot 3H_2O$)	6	421	400	W
Other inorganic aluminum compounds[1]	XX	XX	XX	34,956

W Withheld to avoid disclosing individual company confidential data. XX Not applicable.
[1]Includes sodium aluminate, light aluminum hydroxide, cryolite, and alums.

Source: Data are based upon Bureau of the Census report Form MA-28E.1, Annual Report on Shipments and Production of Inorganic Chemicals.

STOCKS

Total inventories of bauxite in the United States declined 2% to 20.4 million long dry tons during 1976. The overall decrease was largely the result of a reduction in stocks at alumina plants. Abrasives producers rebuilt inventories, which had been reduced significantly in 1975. Government stockpiles of bauxite were unchanged.

The Government stockpile at the end of 1976 was composed of 8,859,000 tons of Jamaica-type bauxite, 5,937,000 tons of Surinam-type bauxite, and 175,000 tons (270,000 tons, dry basis) of calcined refractory-grade bauxite. About 637,000 tons of the Surinam-type bauxite had been sold but not removed from the stockpiles.

Inventories of alumina and related products at plants producing alumina and primary aluminum declined to an estimated 1.3 million short tons. The Government held no stocks of alumina except in the form of abrasive grain and crude fused aluminum oxide. These stockpiles were reduced 5% to 322,000 short tons.

In October the Federal Preparedness Agency proposed new government stockpile goals which would replace the previously established stockpile objectives for various strategic materials. The following were included in the proposed new goals:

Bauxite:		
Metal grade:		
Jamaica type	long dry tons	523,000
Surinam type	do	--
Refractory grade	long calcined tons	2,083,000
Alumina	short tons	11,532,000
Aluminum	do	--

Table 10.—Stocks of bauxite in the United States[1]

(Thousand long tons, dry equivalent)

Sector	Dec. 31, 1975	Dec. 31, 1976
Producers and processors	r486	496
Consumers[2]	r5,209	4,869
Government	15,066	15,066
Total	r20,761	20,431

rRevised.
[1]Domestic and foreign bauxite; crude, dried, calcined, activated; all grades.
[2]Includes bauxite stockpiled by the U.S. Government during World War II and purchased by Reynolds Metals Co.

Table 11.—Stocks of alumina in the United States [1]

(Thousand short tons)

Sector	Dec. 31, 1975	Dec. 31, 1976e
Producers	217	180
Primary aluminum plants	1,241	1,120
Total	1,458	1,300

eEstimate.
[1]Excludes consumers stocks other than those at primary aluminum plants.

PRICES

Prices on most of the bauxite and alumina produced throughout the world are not quoted because the large tonnages used by the aluminum industry are usually obtained from affiliated companies or purchased under long-term negotiated contracts.

Bureau of Mines estimates of the value of domestic production were based on incomplete data supplied by producers. The Bureau's estimated average value of crude domestic bauxite shipments in 1976, f.o.b. mine or plant, was $11.30 per long ton. The average value of shipments of domestic calcined bauxite was estimated at $67 per ton. Bauxite values among producers varied widely because of differences in grade.

The value of imported bauxite consumed at alumina plants in the United States was believed to have increased in 1976, but sufficient company data were not available to determine an average value. Prices published by Engineering and Mining Journal for supercalcined refractory-grade bauxite from Guyana, car lots, f.o.b. Baltimore, Md., or Mobile, Ala., increased about $12 per ton to $119.16 per long ton in January 1976 and remained at that level throughout the year.

The estimated average value of domestic calcined alumina shipments was $132 per short ton. Shipments of alumina trihydrate also averaged $132 per ton. The average value of imported alumina (including small quantities of hydrate), as reported by the Bureau of the Census, was $111.60 per ton at port of shipment and $119 per ton at U.S. ports (c.i.f.). Exports of alumina from the United States and the Virgin Islands averaged $138.10 per ton.

Table 12.—Average value of U.S. imports of crude and dried bauxite in 1976[1]

(Per long ton)

Country[2]	Port of shipment (f.a.s.)	Delivered to U.S. ports (c.i.f.)
Dominican Republic	$26.19	$30.12
Guinea	18.90	26.44
Guyana	25.20	34.30
Haiti	27.51	31.65
Jamaica	25.85	28.54
Surinam	22.35	30.16
Other	10.00	17.70
Weighted average	24.16	28.74

[1]Not adjusted for moisture content.
[2]Excludes bauxite imported into the U.S. Virgin Islands.

Source: Based on data reported to U.S. Customs Service and compiled by the Bureau of the Census, U.S. Department of Commerce.

Table 13.—Market quotations on alumina and aluminum compounds

(In bags, carlots, freight equalized)

Compound		Jan. 2, 1976	Dec. 31, 1976
Alumina, calcined	per pound	$0.08	$0.079
Alumina, hydrated, heavy	do	.06	.059
Alumina, activated, granular, works	do	.1365	0.16-.18
Aluminum sulfate, commercial, ground (17% Al_2O_3)	per ton	111.00	121.00
Aluminum sulfate, iron-free, dry (17% Al_2O_3)	do	140.00	140.00

Source: Chemical Marketing Reporter.

FOREIGN TRADE

U.S. exports classified as "bauxite and concentrates of aluminum excluding alumina" totaled 15,000 long tons in 1976 and were valued at $1.3 million. Canada received 91% of the total and the United Kingdom about 7%.

Exports of alumina, including 35,000 short tons of aluminum hydroxide, increased 13% to 1,158,000 tons. The total included shipments of 272,000 tons to the U.S.S.R. and 37,000 tons to Venezuela from the alumina plant in the U.S. Virgin Islands. Most of the remaining exports were shipments from domestic alumina plants on the Gulf Coast to affiliated aluminum plants in Canada, Ghana, Mexico, and Norway.

Aluminum sulfate exports increased for the fourth successive year and totaled 51,000 short tons at a reported value of $1.6 million. About 33,000 tons was shipped to Brazil, 8,000 tons to Venezuela, and 6,000 tons to Canada. Exports of artificial corundum or fused aluminum oxide decreased 19% to 22,000 tons, valued at $14.8 million. Canada, the largest recipient among 55 countries, received 8,000 tons. Exports classified as "other aluminum compounds" declined slightly to 41,000 tons, valued at $21 million. Much of the tonnage in this category was believed to be aluminum fluoride and synthetic cryolite shipped to other countries for use as a flux in making primary aluminum. About 12,000 tons was shipped to Canada, 9,000 tons to Ghana, and 6,000 tons to Surinam.

The United States imposed no duties on imports of bauxite, alumina, or aluminum hydroxide in 1976. All duties on these commodities were suspended in 1971.

Imports of crude, partially dried, and dried bauxite into the United States and the U.S. Virgin Islands increased 9% to 12.5 million long tons from 11.5 million tons (revised) in 1975. The increase was attributed to a partial recovery in demand for aluminum, which resulted in the reactivation of some of the domestic aluminum and alumina facilities shut down in 1975. Receipts increased from all major import sources except Surinam and the Dominican Republic. Jamaica provided about half of the total, and Guinea provided nearly one-quarter. Receipts from Surinam were 12% of the total, down from about 20% in 1973 and 30% in 1966. Guyana and Haiti each provided 5% of the 1976 total, and the Dominican Republic supplied 4%.

Calcined bauxite imports dropped 11% to 309,000 long calcined tons. Most of these imports were refractory-grade bauxite from Guyana. Additional calcined bauxite was imported into Canada from Surinam and Australia for manufacture into crude fused aluminum oxide, much of which was subse-

Table 14.—U.S. exports of alumina,[1] by country

(Thousand short tons and thousand dollars)

Country	1974 Quantity	1974 Value	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Australia	5	1,098	2	896	2	862
Canada	266	25,336	217	30,350	314	47,912
France	2	672	2	556	4	1,329
Germany, West	5	2,103	4	2,565	4	3,091
Ghana	241	15,542	156	15,112	243	29,410
Italy	4	1,147	(2)	228	(2)	36
Japan	8	5,931	4	4,329	2	2,879
Mexico	128	11,121	131	16,483	124	17,407
Norway	r191	r20,763	r164	r19,961	48	5,390
Poland	(2)	18	(2)	21	28	3,248
Sweden	6	888	1	442	29	3,420
U.S.S.R	r94	r8,338	r158	r16,935	272	26,808
United Kingdom	5	1,998	4	2,181	6	2,509
Venezuela	54	5,082	104	9,812	73	9,503
Yugoslavia	(2)	16	69	7,258	--	--
Other	13	5,900	13	6,944	9	6,114
Total	1,022	105,953	1,029	134,073	1,158	159,918

rRevised.
[1]Includes exports of aluminum hydroxide: 1974—28,000 tons, 1975—24,000 tons, 1976—35,000 tons; includes alumina exported from the U.S. Virgin Islands to foreign countries: 1974—284,000 tons, 1975—263,000 tons, 1976— 309,000 tons.
[2]Less than 1/2 unit.

quently used in abrasive and refractory products in the United States.

Alumina imports, including small quantities of aluminum hydroxide, rose 3% to 3.6 million short tons. Shipments from Australia, largely to aluminum plants in the Pacific Northwest, increased 28% and provided 76% of the total imports. Receipts from the other two principal suppliers, Jamaica and Surinam, declined.

Table 15.—U.S. imports for consumption of bauxite, crude and dried, by country[1]

(Thousand long tons)

Country	1974	1975	1976
Australia	73	93	--
Dominican Republic[2]	[r]1,190	[r]742	509
Greece	--	26	--
Guinea	1,670	2,598	3,016
Guyana	749	295	635
Haiti	[2]586	495	606
Jamaica[2]	7,766	5,396	6,185
Sierra Leone	23	27	53
Surinam	2,907	1,857	1,544
Other	12	--	(3)
Total	[r]14,976	[r]11,529	12,548

[r]Revised.
[1]Includes bauxite imported into the U.S. Virgin Islands from foreign countries: 1974—761,000 tons, 1975—939,000 tons, 1976—902,000 tons.
[2]Dry equivalent of shipments to the United States.
[3]Less than 1/2 unit.

Table 16.—U.S. imports for consumption of bauxite (calcined), by country

(Thousand long tons and thousand dollars)

Country	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
China, People's Republic of	1	31	14	350	11	861
Guyana	252	17,433	255	22,585	263	22,546
Surinam	50	2,153	64	2,291	33	1,790
Trinidad and Tobago[1]	--	--	15	1,463	(2)	25
Other	1	115	(2)	3	2	176
Total	304	19,732	348	26,692	309	25,398

[1]Shipments probably originated in Guyana or Surinam.
[2]Less than 1/2 unit.

Table 17.—U.S. imports for consumption of alumina,[1] by country

(Thousand short tons and thousand dollars)

Country	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	2,202	154,376	2,154	201,748	2,751	284,497
Canada	20	2,322	21	3,289	14	2,504
Finland	4	1,798	--	--	--	--
France	9	9,554	11	14,563	10	13,734
Germany, West	6	2,605	4	2,126	6	3,485
Guyana	10	609	22	1,651	13	839
Italy	--	--	29	2,673	--	--
Jamaica	902	69,241	779	96,609	616	79,526
Surinam	473	29,489	487	46,969	210	18,699
Other	1	623	(2)	411	4	1,194
Total	3,627	270,617	3,507	370,039	3,624	404,478

[1]Includes small quantities of aluminum hydroxide; excludes shipments from the U.S. Virgin Islands to the United States: 1974—83,000 tons ($9,210,000), 1975—131,000 tons ($16,410,000), 1976—165,000 tons ($19,394,000).
[2]Less than 1/2 unit.

WORLD REVIEW

World production of bauxite increased an estimated 2% in 1976. The largest increases occurred in Australia and Guinea. Australia, the largest producer, accounted for 31% of the world total, and Guinea and Jamaica accounted for 14% and 13%, respectively. Of the countries showing lower production in 1976, Jamaica, Guyana, and Greece registered the largest declines.

World alumina production increased 3% during 1976. Australia became the world's largest producer as its output surpassed that of the United States. Australia and the United States had the largest increases in alumina production, and together the two countries produced 45% of the world total. The countries showing the largest declines were Canada and Jamaica.

Studies continued on the proposed bauxite-alumina-aluminum joint venture of the Caricom countries, Jamaica, Guyana, and Trinidad and Tobago. In this venture, bauxite and alumina would be supplied by Jamaica and Guyana, and a primary aluminum plant based on natural gas or oil would be constructed at Point Lisas, Trinidad. A second phase of the project would include an aluminum plant in Guyana based on hydroelectric power.

Australia.—Three companies, Alcoa of Australia (W.A.) Ltd., Comalco Ltd., and Nabalco Pty. Ltd., accounted for all of the bauxite production in Australia, the world's largest producing country. Alumina was produced at four plants, two of which were operated by Alcoa, one by Queensland Alumina Ltd., an affiliate of Comalco, and one by Nabalco.

Alcoa of Australia was owned by Aluminum Co. of America (51%), Western Mining Corp. Ltd. (20%), Broken Hill South Ltd. (16.6%), North Broken Hill Ltd. (12%), and two other companies (0.4%). Alcoa's alumina plants were located in Western Australia and supplied with bauxite from the Darling Range. The alumina plant at Kwinana received bauxite from mines near Jarrahdale, and the Pinjarra refinery was supplied by the Del Park and Huntly mines north of Dwellingup.

Comalco, owned by Kaiser Aluminum & Chemical Corp. (45%), Conzinc Riotinto of Australia, Ltd. (45%), and the public (10%), produced bauxite in the Weipa area of Cape York Peninsula, Queensland. Output increased about 1% to a record 9.5 million long tons in 1976. Shipments declined slightly to 8.9 million tons, of which 53% went to the Queensland Alumina refinery at Gladstone, 16% to Japan, and 31% to Europe and other areas. Comalco also produced calcined bauxite and reported that production and sales of this product were at record levels.

Production of alumina by Queensland Alumina totaled 2.27 million short tons, an increase over that of 1975, despite a strike which halted production for 1 week. Queensland Alumina was owned by Kaiser (32.3%), Alcan Aluminium Ltd. (21.4%), Pechiney Ugine Kuhlmann Group (PUK) (20%), Comalco (13.8%), and Conzinc Riotinto of Australia (12.5%). A tentative agreement was reached by Comalco's major stockholders to rearrange the ownership of Queensland Alumina. If the necessary approvals are obtained, Comalco will purchase all of Conzinc Riotinto's interest in Queensland Alumina and a 4% interest from Kaiser.

Nabalco, owned by Swiss Aluminium Ltd. (Alusuisse) (70%) and Gove Alumina Ltd. (30%), produced bauxite and alumina near Gove, Northern Territory. Bauxite production in 1976 totaled about 4.4 million long tons, and alumina output reportedly reached 1,135,000 short tons, exceeding the rated annual plant capacity.

Plans to construct a large new alumina plant at Wagerup, Western Australia, about 75 miles south of Perth, were announced in December. A preliminary understanding was reached by the prospective participants, which included Reynolds Metals Co., Alcoa of Australia, and Alwest Pty., Ltd., a joint venture of News Ltd. and Dampier Mining Co. Ltd. Other companies were to be invited to participate in the consortium.

Brazil.—Mineração Rio do Norte S.A. signed a contract in January with Construtora Andrade Gutierrez for construction of Rio do Norte's bauxite project on the Trombetas River in the Amazon Basin. The construction, which will include a 19-mile railroad, ore treatment and shipping facilities, a town, and other infrastructure, was expected to be completed within 3 years at a cost of about $300 million. The project will have an initial bauxite production capacity of 3.3 million long tons. Reserves have been reported at 500 million tons, averaging, on a washed basis, about 56% Al_2O_3 and 5% SiO_2, plus an additional 100 million tons of slightly lower grade bauxite. Rio do Norte was a consortium consisting of the Brazilian Government's Cia. Vale do Rio Doce (CVRD), 41%; Alcan Aluminium Ltd., 19%; Cia. Brasileira de Aluminio S.A., 10%; Reynolds Metals Co., 5%, and five European companies, 25%.

Total bauxite reserves in the Trombetas area, including the concessions of Rio do Norte and subsidiaries of Alcoa and National Bulk Carriers, have been estimated at 2 billion tons. Alcoa, operating through its subsidiary, Cia. de Mineração Santarem S.A. (COMISA), continued to evaluate its concessions west of the Rio do Norte project and submitted feasibility studies to the Government. Reynolds was active in exploration of its concessions on the south bank of the Amazon west of Santarem.

In the Paragominas area south of Belém, Mineração Vera Cruz Ltda., a subsidiary of Rio Tinto Zinc (RTZ), and CVRD were conducting exploration on separate concessions. RTZ completed construction of a pilot plant for crushing and washing bulk samples and was preparing a feasibility study, which was scheduled for completion by the end of 1977. It was reported that CVRD may join with RTZ in developing the RTZ deposit to supply a proposed alumina plant near Belém.

An agreement was reached between CVRD and Japanese interests to construct an alumina plant (the Alunorte project) and an aluminum smelter (the Albras project) near Belém based on the use of hydroelectric power from the Tocantins River. The joint venture was to be owned 51% by CVRD and 49% by 32 private Japanese companies. The alumina plant would have an annual capacity of 880,000 short tons and would cost an estimated $409 million.

Alcan obtained approval to expand the facilities of its subsidiary, Alcan Aluminio do Brazil S.A., at Saramenha in Minas Gerais. The capacity of the alumina plant will be increased by 33,000 tons to 133,000 tons, and construction was expected to begin in 1977.

Canada.—Alumina production at Alcan's plant in Quebec Province declined over 50% in 1976, largely because of strikes at the company's alumina and aluminum plants.

Greece.—Bauxite production in Greece declined 15% to 2.7 million long tons in 1976. Greek bauxite was used to supply the alumina plant of Aluminium de Grece S.A. at Distomon, and most of the remaining output was exported. Total licensed exports for 1977 were reduced 28% to 2,264,000 tons, with the largest allocations going to the European Economic Community, the U.S.S.R., and Romania.

Bauxites Parnasse Mining S.A., the largest bauxite producer in Greece, was undergoing a $10 million investment program to increase annual production capacity at its Parnassos-Ghiona mines in central Greece from 2 million tons to 3.5 million tons. The program will include an expansion of underground facilities from about 500,000 tons to 1.5 million tons annual capacity by 1982. Bauxite Parnasse is the principal Greek partner in a planned 660,000 short-ton-per-year alumina plant to be constructed near Itea on the Gulf of Corinth.

The second largest bauxite producer, Eleusis Bauxite Mines, Inc. (Scalistiri group), was reported to have an annual bauxite mining capacity of 720,000 tons, including 200,000 tons from Aluminium de Grece's Delphi Bauxites S.A. mines, which were operated by Eleusis. Barlos Bauxite Hellas S.A. was reported to be producing at a level of about 200,000 tons in 1976. Both Eleusis and Barlos were increasing production capacity during the year. Other bauxite producers included Distomon Hellenic Bauxites, controlled by Aluminium de Grece, with an annual production of 270,000 tons, and Elikon Bauxites-G. Barlos S.A., with an annual capacity of 200,000 tons.

Guinea.—Guinea Bauxite Co. (CBG), owned by Halco (51%) and the Government of Guinea (49%), was the largest of three bauxite producers in Guinea and produced a reported 6.4 million long tons in 1976. Halco was a consortium of aluminum producers consisting of Alcoa (27%), Alcan (27%), Martin Marietta Aluminum, Inc. (20%), PUK (10%), Vereinigte Aluminium-Werke AG (VAW) (10%), and Alumetal S.p.A. (6%). The bauxite was mined at Sangaredi, shipped by rail to the treatment plant and port at Kamsar, and exported largely to members of Halco. Bauxite exported by CBG averaged over 59% Al_2O_3 (less than 3% monohydrate) and about 1% SiO_2.

Kindia Bauxite Office (OBK), owned by the Government of Guinea and operated with U.S.S.R. assistance, produced about 2.4 million tons of bauxite, averaging 46% to 48% Al_2O_3 and 2% SiO_2. The ore is mined at Débélé in the Kindia region, shipped by rail to Conakry, and exported to the U.S.S.R. [4]

The third bauxite producer, Friguia, also operated the only alumina plant in Africa. Friguia was owned by Frialco (51%) and the Government (49%); Frialco was a consortium consisting of Noranda Mines Ltd. (38.5%), PUK (36.5%), British Aluminium

[4]Wyllie, R. J. M. OBK, Guinea's National Bauxite Company, Operates 2,500,000 Ton Mine and Railroad. World Mining, v. 29, No. 4, April 1976, pp. 72-75.

Co., Ltd. (10%), Alusuisse (10%), and VAW (5%). Bauxite production by Friguia totaled 1.8 million tons during the year, and alumina production declined 13% to 617,000 short tons.

The Governments of Guinea, Egypt, Iraq, Kuwait, Libya, Saudi Arabia, and the United Arab Emirates have agreed to a joint venture to build a large bauxite-alumina complex to exploit the bauxite deposits at Ayékoyé near the CBG concession. The project will cost an estimated $1 billion. Reportedly Alusuisse has agreed to conduct feasibility studies and preliminary design for the venture.

Guyana.—Bauxite was produced by two government-owned companies, Guyana Bauxite Co. (Guybau) and Berbice Mines (Bermine). In addition to the production of metal-grade bauxite, Guyana continued to be the world's largest supplier of high-grade calcined bauxite for refractory uses. Guyana also produced alumina. Production of both grades of bauxite and alumina decreased in 1976 because of heavy rains early in the year, strikes at yearend, and depressed markets for alumina. Shipments of metal-grade bauxite to the United States increased, reflecting a reported contract with Reynolds for 300,000 to 400,000 tons.

It was reported that Guybau will replace the rotary-kiln facilities at its alumina plant with fluidized-bed calciners, which were expected to reduce energy requirements by 30% to 40%. The new facilities were to be built by the West German company Lurgi Chemie und Huettentechnik and completed by 1978.

Haiti.—The Haitian Government and Reynolds Haitian Mines, Inc., reached an agreement covering bauxite taxes and export quotas for the 5-year period 1977-81.

Hungary.—A new bauxite mine, Iza-II, near Tapolca in western Hungary, was reported to have begun production at an annual rate of over 400,000 tons.

India.—The Government continued its program of exploration and evaluation of bauxite deposits in the east coast States of Orissa and Andhra Pradesh. The bauxite belt being investigated was said to extend about 185 miles in a northeast-southwest direction and to be 25 to 60 miles wide. Much of the bauxite was reported to be in deposits ranging from 20 feet to over 100 feet thick, with little overburden. Preliminary estimates of reserves in this area were about 1 billion tons. Reportedly, the bauxite has a high iron content (19% to 26%) but is low in silica (2% to 4%). The Government company Bharat Aluminium Co. was expected to be granted mining leases for these deposits. Proposals to construct alumina plants based on this bauxite were being considered.

Jamaica.—It was reported that the Jamaica Bauxite Institute, an agency of the Government of Jamaica, had reestimated total bauxite reserves on the island at 2 billion tons.

Bauxite and alumina were produced by affiliates of five North American aluminum companies. In addition to the bauxite produced to supply the four alumina plants operated during the year, Jamaican bauxite was exported to U.S. alumina plants by Kaiser Bauxite Co., Reynolds Jamaica Mines Ltd., and Alcoa Minerals of Jamaica, Inc. Exports of bauxite increased 15% to 6.2 million long tons (dry basis) in 1976, while exports of alumina decreased 32% to 1.8 million short tons.

The levy on bauxite production was increased by the Government from 7.5% to 8.0% of the price realized on primary aluminum ingot. Assuming a realized aluminum price of 42 cents per pound, the new production levy would amount to $15.62 per long dry-ton of bauxite. Any increase in the price received for primary aluminum above 42 cents per pound would increase the bauxite levy proportionately. Reportedly, a levy rate of less than 8% will apply under agreements reached with several producers.

In October, Alcoa and the Government of Jamaica agreed to form a joint bauxite and alumina venture to be known as Jamalco. Under the 40-year agreement, Alcoa will sell the Government a 6% interest in its mining and refining assets and all of its mining and nonoperating lands. Alcoa will receive a reduced bauxite levy rate for the first 8 years of the agreement and will continue to manage the alumina plant.

Alcoa's alumina plant was shut down for two 3-month periods during 1976. Labor disputes caused Alcoa to suspend operations from mid-February to early May. Two months later an explosion of a pressure vessel forced a second plant closure. The plant was reopened in October and operated at half capacity the remainder of the year.

Total production of alumina at the two plants owned by Alcan Jamaica Ltd. was down 19% to 841,000 short tons. The decline was attributed to both lower demand and a strike at one of the plants. Talks between the Government and Alcan regarding such questions as the ownership of bauxite reserves and government participation in the company's equity were conducted during the year.

The alumina plant and mines of Revere Jamaica Alumina, Ltd., were closed down in August 1975 and remained closed throughout 1976. Revere initiated a suit against the Government challenging the validity of the bauxite production levy as applied to Revere and seeking confirmation that its mining lease remained valid. Revere also filed a claim with the Overseas Private Investment Corp. (OPIC), a U.S. Government insurance agency, under the expropriation provisions of its policy with OPIC. Neither of these actions was resolved at yearend.

Japan.—Japan continued to rely on imports for virtually all of its aluminum raw materials. Bauxite imports in 1976 totaled 4.2 million long tons, of which 2,674,000 tons came from Australia, 952,000 tons from Indonesia, 504,000 tons from Malaysia, and 80,000 tons from other sources, largely Guyana. An additional 682,000 short tons of alumina, all from Australia, was imported for use in making aluminum. Mitsui Alumina Corp. completed installation of new facilities which doubled the alumina production capacity at its Wakamatsu plant.

Sierra Leone.—Sierra Leone Ore and Metal Co., a wholly owned subsidiary of Alusuisse, operated the only bauxite mine in Sierra Leone at Mokanje. Alusuisse was reported to be considering the opening of a new bauxite mine in the Port Loko area and the possibility of constructing an alumina plant. If plans for the new mine materialize, Alusuisse may be joined in the venture by the Norwegian aluminum producers, A/S Ardal og Sunndal Verk and Norsk Hydro A/S. The Government reached agreement with Alusuisse and passed legislation in 1976 to increase its total bauxite revenues accruing from royalties, mining leases, and income tax.

South Africa, Republic of.—A discovery of large low-grade bauxite deposits in the Midlands and Zululand of Natal was reported.

Spain.—An 880,000-ton-per-year-capacity alumina plant was under construction at San Cipriano in 1976. The plant will be owned by the Spanish aluminum companies Empresa Nacional del Aluminio, S.A., 55%, and Aluminio de Galicia, S.A., 45%, and was scheduled to begin production in 1979.

Surinam.—Metallurgical and special grades of bauxite were mined by Surinam Aluminum Co. (Suralco), an Alcoa subsidiary, in the Moengo area of eastern Surinam and by Suralco and N.V. Billiton Mij. Suriname in the Paranam area. Billiton's bauxite mining operations were described.[5] Suralco also produced alumina and aluminum and converted bauxite to alumina for Billiton. Total exports of bauxite, most of which was shipped to the United States, decreased 13% to just under 2 million long tons in 1976. Exports of alumina declined slightly to 1.2 million short tons, as reduced shipments by Suralco offset an increase by Billiton.

The Government of Surinam and Suralco reached an agreement on the payment of bauxite production levies over the 3-year period ending December 31, 1978. The tax will be based, as it had been since 1974, on a rate of 6% of the price Alcoa receives on unalloyed primary metal. It was reported that the company also agreed to produce a minimum of about 8.2 million long tons of bauxite during the 3-year period.

Grasshopper Aluminium Co. Ltd. (Grassalco), a Government-owned company, was developing plans to mine lateritic-type bauxite in the Bakhuis Mountains of western Surinam. A prefeasibility study of two areas in the Bakhuis Mountains was conducted for Grassalco by Billiton in 1976, and Grassalco reported reserves totaling over 50 million tons of bauxite containing at least 42% available alumina. A 44-mile railroad will be built from the deposits to Apoera on the Corantijn River bordering Guyana, and a $60 million contract for its construction was awarded to a joint venture sponsored by Morrison-Knudsen International Co. Shipments of bauxite from these deposits were scheduled to begin in 1979. The feasibility of constructing an alumina plant at Apoera was also being studied.

U.S.S.R.—The bauxite and other aluminum resources of the U.S.S.R., a history of their use, and the trend toward the U.S.S.R. dependence on imported aluminum raw materials were described.[6]

Venezuela.—It was reported that Alusuisse and Corporación Venezolana de Guay-

[5] Argall, G. O., Jr. Bucket Wheels, Dredges, Draglines Strip and Mine at Billiton Suriname. Min. World, v. 29, No. 3, March 1976, pp. 46-51.

[6] Shabad, T. Raw Material Problems of the Soviet Aluminum Industry. Resources Policy, v. 2, No. 4, December 1976, pp. 222-234.

ana (CVG) would form a joint venture to produce alumina in Venezuela. The venture would be named Interamericana de Alúmina C.A. (INTER-ALUMINA) and would be owned by Alusuisse (20%) and CVG (80%). The proposed alumina plant would have an annual capacity of 1 million tons, would cost an estimated $550 to $600 million, and would be located in the Guayana region of Venezuela. The plant would provide 800,000 tons of alumina per year to supply the Venalum and Alcasa primary aluminum plants and 200,000 tons for export by Alusuisse. Production would be based on imported bauxite, and natural gas available in the area would provide the required energy.

Yugoslavia.—Expansion of bauxite and alumina production facilities continued in Yugoslavia. A new alumina plant at Obrovac, Croatia, was reported to be producing at yearend at the rate of 110,000 short tons per year. The plant eventually will have a capacity of 330,000 tons. Another new alumina plant was under construction at Zvornik, Bosnia-Hercegovina, for Energoinvest. The Zvornik plant will have an annual capacity of 660,000 tons, half of which was expected to come onstream in 1977. It was also announced that the alumina plant at Titograd, Montenegro, would be expanded from 220,000 tons to 310,000 tons.

Table 18.—Bauxite: World production, by country

(Thousand long tons)

Country[1]	1974	1975	1976[p]
North America:			
Dominican Republic[2] [3]	1,190	742	508
Haiti[4]	649	514	650
Jamaica[2] [5]	15,086	11,388	10,143
United States[2]	1,949	1,772	1,958
South America:			
Brazil	[r]845	954	[e]985
Guyana[e] [2]	3,200	3,200	2,600
Surinam[e]	6,600	4,850	4,500
Europe:			
France	[r]2,892	2,523	2,293
Germany, West	1	1	1
Greece	2,739	3,193	2,703
Hungary	[r]2,708	2,843	2,872
Italy	31	32	24
Romania	844	767	[e]790
Spain	8	11	[e]11
U.S.S.R.[e] [6]	4,200	4,300	4,400
Yugoslavia	2,333	2,270	2,001
Africa:			
Ghana	357	314	263
Guinea	7,480	[e]9,000	10,676
Mozambique	[r]5	2	[e]2
Rhodesia, Southern[e]	2	2	2
Sierra Leone	661	705	650
Asia:			
China, People's Republic of[e] [7]	950	950	1,100
India	[r]1,096	1,253	1,413
Indonesia	1,270	977	925
Malaysia	933	692	650
Pakistan	([8])	--	[e]([8])
Turkey	654	621	512
Oceania: Australia	[r]19,679	20,627	23,705
Total	78,362	74,503	76,337

[e]Estimate. [p]Preliminary. [r]Revised.

[1]Data do not include estimated bauxite equivalent of nepheline concentrate and alunite ores produced in the U.S.S.R. as source materials for alumina.

[2]Dry bauxite equivalent of crude ore.

[3]Shipments.

[4]Dry bauxite equivalent of ore processed by drying plant.

[5]Bauxite processed for conversion to alumina in Jamaica plus exports of kiln-dried ore.

[6]Excludes materials other than bauxite used for production of alumina, estimated as follows in thousand long tons: Nepheline syenite (25% to 30% alumina): 1974-[r]2,950, 1975-[r]3,300, 1976-3,400; alunite ore (16% to 18% alumina): 1974-[r]500, 1975-[r]600, 1976-600.

[7]Diasporic bauxite; includes an estimated annual production of 160,000 tons for refractory applications.

[8]Less than 500 tons.

Table 19.—Alumina: World production,[1] by country

(Thousand short tons)

Country[2]	1974	1975	1976[p]
North America:			
Canada	1,394	1,250	[e]500
Jamaica	3,165	2,489	1,793
United States	7,589	5,660	[e]6,400
South America:			
Brazil	[e]240	266	[e]275
Guyana	354	343	309
Surinam	[r]1,306	1,265	1,274
Europe:			
Czechoslovakia[e]	110	110	110
France	1,229	1,206	1,124
Germany, East	53	53	[e]53
Germany, West	1,441	1,374	1,470
Greece	[r]544	523	495
Hungary	[r]783	855	[e]860
Italy[e]	[r]810	[r]820	820
Romania[e]	410	440	440
United Kingdom	104	91	[e]100
U.S.S.R.[e]	[r]2,500	[r]2,600	2,800
Yugoslavia	301	312	[e]511
Africa: Guinea	733	709	617
Asia:			
China, People's Republic of[e]	440	460	570
India	[r]359	371	480
Japan	1,985	1,725	1,556
Taiwan	50	51	[e]50
Turkey	[r]136	90	[e]138
Oceania: Australia	[r]5,401	5,652	6,841
Total	[r]31,437	28,715	29,586

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Figures presented generally represent calcined alumina equivalent of total alumina production.
[2]In addition to the countries listed, Austria produces alumina (fused aluminum oxide), but output is entirely for abrasives production. Output totaled 31,110 short tons in 1973; production data for 1974-76 are not available.

Table 20.—World annual alumina capacity

(Thousand short tons, yearend)

Country	1974	1975	1976
North America:			
Canada	1,387	1,387	1,387
Jamaica	3,310	3,359	3,359
United States	7,770	7,805	7,805
South America:			
Brazil	285	365	431
Guyana	390	390	390
Surinam	1,490	1,490	1,490
Europe:			
Czechoslovakia	110	110	110
France	1,435	1,460	1,440
Germany, East	70	70	70
Germany, West	1,916	1,916	1,906
Greece	540	551	551
Hungary	[e]800	[e]800	851
Italy	1,025	1,014	1,014
Romania	550	550	550
United Kingdom	110	110	138
U.S.S.R.[e]	3,500	3,500	3,500
Yugoslavia	374	683	793
Africa: Guinea	772	772	772
Asia:			
China, People's Republic of [e]	400	400	500
India	710	725	749
Japan	2,709	2,709	2,904
Taiwan	84	84	84
Turkey	220	220	220
Oceania: Australia	5,805	7,385	7,430
Total	35,762	37,855	38,444

[e]Estimate.

TECHNOLOGY

Research and development of processes to use nonbauxitic aluminum resources was continued in countries with insufficient bauxite resources by both government and private organizations.[7]

The Federal Bureau of Mines continued its research program on the recovery of alumina from clay, anorthosite, and other raw materials abundant in the United States. The most promising technologies for extracting alumina were being tested and developed in small pilot plants, or miniplants, at the Bureau's Boulder City (Nevada) Metallurgy Engineering Laboratory. Additional research in support of this effort was being conducted at other Bureau research centers.[8] The miniplant program was initiated to evaluate the various processes on a comparative basis and to obtain cost and engineering data for the design and operation of large-scale demonstration plants. Nine companies were participating with the Bureau in the miniplant project on a cooperative cost-sharing basis.

In 1976 the major emphasis of the miniplant program was on the hydrochloric acid process for recovering alumina from clay, and test runs of several sections of this miniplant were completed. The clay-nitric acid miniplant was placed on standby status, and the design was completed and equipment was ordered for facilities to recover alumina from anorthosite using a lime-sinter process. At yearend the Bureau awarded a $1.6 million contract to Kaiser Engineers to evaluate several of the alumina processes being tested by the Bureau and, subsequently, to design a larger pilot plant based on a process which will be selected by the Bureau.

The Bureau reported on its investigations of the potential for recovering aluminum from copper-dump leach liquors by the use of single-contact ion-exchange technology.[9]

Dawsonite, an aluminum mineral occurring in the oil shales of the Piceance Creek Basin in Colorado, has been of interest as a potential source of alumina should the shales be mined to recover oil. The Bureau placed on open file reports which explore the technical and economic feasibility of three different methods of developing these oil shale deposits.[10] Another process to recover oil, alumina, nahcolite, and soda ash was under investigation by Superior Oil Co.[11]

A joint venture of Earth Sciences, Inc., National Steel Corp., and Southwire Co. continued its research and planning for the production of alumina and fertilizer byproducts using alunite deposits in southwestern Utah. A pilot plant program and preliminary engineering and cost analysis were reported to be near completion at yearend. An environmental impact statement for the project, which would produce 500,000 tons per year of alumina, was being prepared.

Iran and the U.S.S.R. were reported to have signed an agreement to build a plant near Tehran to produce alumina from alunite deposits in Iran using Russian technology. The plant would have a capacity of 550,000 tons per year and cost an estimated $600 million.

Aluminium Pechiney and Alcan completed construction of a pilot plant near Marseilles, France, in September. The plant will test the H-Plus process, which uses both sulfuric acid and hydrochloric acid to recover high-purity alumina from shale, clay, and other low-grade aluminous materials. The plant was designed to produce 20 tons of alumina per day.

A/S Ardal og Sunndal Verk and Elkem Spigerverket, two Norwegian aluminum companies, were reported to have constructed a pilot plant for testing a new process for extracting alumina from anorthosite. The two firms have acquired rights to large anorthosite deposits containing about 30% Al_2O_3 in western Norway.

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[7]Patterson, S. H. Aluminum From Bauxite: Are There Alternatives? Am. Scientist, v. 65, No. 3, May-June 1977, pp. 345-351.

[8]Eisele, J. A., L. E. Schultze, D. J. Berinati, and D. J. Bauer. Amine Extraction of Iron From Aluminum Chloride Leach Liquors. BuMines RI 8818, 1976, 10 pp.

[9]May, J. T., and D. C. Seidel. Recovering Aluminum From Copper Leach Liquor by Ion Exchange, An Exploratory Study. BuMines RI 8174, 1976, 22 pp.

[10]U.S. Department of the Interior News Release. Preliminary Research Reports Issued on Potential Large-Scale Oil Shale Development. June 15, 1976, 2 pp.

[11]Chemical Engineering News. Prognosis Good for New Shale Oil Process. V. 55, No. 2, Jan. 10, 1977, pp. 27-28.

Beryllium

By Benjamin Petkof[1]

Bertrandite was the major commercial beryllium mineral produced in the United States, and it contributed a significant proportion of the world beryllium mineral supply. A small quantity of beryl was also produced domestically. Ore consumption and imports declined, but exports of beryllium materials increased.

Legislation and Government Programs.—On October 1, 1976, the Federal Preparedness Agency of the General Services Administration, issued new goals for beryllium materials in the strategic stockpile: Beryl, 0; beryllium-copper master alloy, 16,710 short tons; and beryllium metal, 895 tons. No beryl was released from the strategic stockpile during the year.

Table 1.—Salient beryllium mineral statistics

	1972	1973	1974	1975	1976
United States:					
Beryl, approximately 11% BeO:					
Shipped from mines short tons	W	W	W	W	W
Imports do	3,345	1,586	1,368	1,479	1,058
Consumption[1] do	7,781	8,695	9,279	4,850	3,740
Price, approximate, per unit BeO, imported cobbed beryl at port of exportation	$30	$30	$30	$30	$33
Bertrandite ore: Utah, low-grade, shipped from mines short tons	W	W	W	W	W
World production of beryl do	4,330	3,963	r3,469	r3,608	3,035

rRevised. W Withheld to avoid disclosing individual company confidential data.
[1]Includes bertrandite ore which was calculated as equivalent to beryl containing 11% BeO.

DOMESTIC PRODUCTION

Bertrandite was the Nation's major source of beryllium ore during the year. Brush Wellman, Inc. (Brush) produced the bertrandite ore at its Spor Mountain mine in Millard County, Utah. A small quantity of beryl production was also reported in South Dakota and Arizona.

Brush converted its ore to beryllium hydroxide at a facility north of Delta, Utah, and then shipped the hydroxide to its Elmore, Ohio, facility for conversion to beryllium oxide, metal, and copper alloys.

Kawecki-Berylco Industries, Inc. (KBI) produced beryllium materials principally from imported beryl. KBI processed beryllium hydroxide at its plants in Hazelton and Reading, Pa., into beryllium metal, alloys, and oxide.

In December 1976, Brush announced plans to build a beryl ore processing facility at its bertrandite processing plant in Utah. The company planned to spend an estimated $4.5 million on the new plant. Upon completion, this will be the only plant capable of processing any commercial beryllium ore to beryllium hydroxide. Brush planned to close its beryl processing facility at Elmore, Ohio, in 1977.

Domestic production of beryllium metal declined in 1976, but production of beryllium containing alloys and beryllium oxide

[1]Physical scientist, Division of Nonferrous Metals.

increased. Improvement in metal production is expected to occur with the inception of new space and nuclear energy programs that specify the use of beryllium metal.

CONSUMPTION AND USES

The domestic beryllium industry consumed beryllium ore equivalent to 3,740 tons of beryl containing a nominal 11% BeO, a decline of 23% from that of 1975.

Beryllium metal, with its high stiffness-to-weight ratio, continued to be used primarily in defense and aerospace applications. The metal was used in the manufacture of commercial and military navigational systems, satellite structures, space vehicle instrumentation and optics, X-ray transmission windows, aircraft brakes and structures, and missile parts.

Products utilizing beryllium-copper alloys accounted for the greatest quantity of beryllium consumption. These alloys were used by the business machine, appliance, transportation, and communications industries. Beryllium-copper alloys were also widely used in electrical and electronic systems for connectors, sockets, switches, and temperature- and pressure-sensing devices to provide reliability and long service life.

Beryllium oxide ceramics were used in lasers, microwave tubes, and semiconductors, primarily for heat dissipation in these devices. In addition, beryllia was used as a substrate in various electronic devices and equipment.

STOCKS

Consumer stocks of beryllium minerals totaled 3,957 tons at yearend 1976, a 12% increase above those of 1975. Dealers' stocks of beryl were not reported.

PRICES AND SPECIFICATIONS

There were no known price quotations for the small quantities of domestically produced beryl. The price of any available domestic beryl was negotiated between buyer and seller. At the beginning of the year, Metals Week quoted the price of imported beryl at $30 per short-ton unit of contained BeO. As of February 12, 1976, to the end of the year, Metals Week quoted the price at $40 to $42 per short-ton unit. At yearend, American Metal Market quoted the following prices for beryllium materials: Vacuum cast ingot, $75 per pound; metal bead (97% purity and 10,000-pound lots), $61 per pound; metal powder (20,000-pound lots), $56 to $63 per pound; metal rod, $125.55 per pound; beryllium-copper master alloy, $59 per pound of contained beryllium; beryllium-copper casting alloy, $2.05 to $2.86 per pound; beryllium-copper in strip, rod, bar, and wire, $4 per pound; beryllium-aluminum alloy ingot, $72 per pound; and beryllium oxide powder, $26 per pound.

FOREIGN TRADE

Exports of wrought, and unwrought beryllium alloys and of waste and scrap increased threefold in quantity over those of 1975 but did not reach the level of 1974. Total value of exports increased 52%, although average value of exports declined from $30.85 per pound to $15.38 per pound, still above the average value of $7.71 for 1974. In terms of quantity, 65% of the total material exported went to Mexico, 11% to Japan, 8% to the United Kingdom, and 4% to France.

Beryl ore imports decreased 28% in quantity and 19% in value from those of 1975. The average value of imported material was $359 per ton in 1976 compared with $316 per ton in 1975. Forty-eight percent of U.S. imports came from Brazil, 11% from India, 10% each from France, and Australia, and 9% from the Republic of South Africa. In addition, 1,492 pounds of wrought and unwrought, waste and scrap beryllium metal valued at $3,117 were imported.

Table 2.—U.S. exports of beryllium alloys, wrought or unwrought, and waste and scrap[1]

Country	1975 Quantity (pounds)	1975 Value (thousands)	1976 Quantity (pounds)	1976 Value (thousands)
Argentina	130	$1	--	--
Austria	--	--	32	$1
Belgium	--	--	4	2
Canada	9,787	75	3,204	63
Finland	414	3	--	--
France	4,528	306	4,718	325
Germany, West	921	53	701	92
Hong Kong	--	--	3,000	8
India	16	1	162	1
Israel	5	1	--	--
Italy	771	30	2,419	49
Japan	5,529	203	12,591	255
Mexico	2,500	2	73,960	61
Netherlands	20	9	1,407	63
Switzerland	1,073	28	2,374	89
Taiwan	100	1	3	5
United Kingdom	11,542	439	9,568	742
Total	37,336	1,152	114,143	1,756

[1]Consisting of beryllium lumps, single crystals, powder, beryllium-base alloy powder; beryllium rods, sheets, and wire.

Table 3.—U.S. imports for consumption of beryl, by customs district and country

Customs district and country	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Philadelphia district:				
Argentina	110	$31	--	--
Australia	--	--	103	$38
Bolivia	--	--	11	3
Brazil	779	276	512	201
France	--	--	103	35
India	--	--	120	46
Portugal	93	32	--	--
Rhodesia, Southern	42	15	--	--
Rwanda	22	3	66	14
South Africa, Republic of	207	50	97	34
Uganda	78	14	44	9
Total	1,331	421	1,056	380
Baltimore district:				
Brazil	33	12	--	--
Mozambique	39	11	--	--
Uganda	38	12	--	--
Total	110	35	--	--
New Orleans district: South Africa, Republic of	[1]38	[1]12	--	--
New York City district: Mozambique	--	--	2	([2])
Grand total	[1]1,479	[1]468	1,058	380

[1]Adjusted by the Bureau of Mines.
[2]Less than 1/2 unit.

WORLD REVIEW

Total world production of beryl declined below that of 1975. Beryl competes with the nonpegmatite mineral bertrandite as a commercial source of beryllium.

The capability of mining and processing Utah bertrandite ore that has been developed during the past 10 to 15 years has made the United States a significant world source of commercial beryllium minerals. Any future increase in U.S. bertrandite mining and processing capability could displace additional world beryl output that is recovered by hand mining and sorting.

Table 4.—Beryl: World production, by country

(Short tons)

Country[1]	1974	1975	1976[p]
Angola[e]	100	35	35
Argentina	125	303	[e]220
Australia	87	--	--
Brazil[e]	1,000	1,000	800
Malagasy Republic	14	17	[e]17
Mozambique	9	[e]10	[e]10
Portugal	17	28	--
Rhodesia, Southern[e]	70	70	70
Rwanda	[r]65	20	--
South Africa, Republic of	2	85	[e]3
Uganda[e]	60	60	60
U.S.S.R.[e]	1,700	[r]1,760	1,820
United States	W	W	W
Zambia	220	220	--
Total	[r]3,469	[r]3,608	3,035

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]In addition to the countries listed, the Territory of South-West Africa may also have produced beryl, but available information is inadequate to formulate reliable estimates of output levels.

TECHNOLOGY

A report provided guidelines for determining beryllium emission rates from stationary sources. The report included guidelines on good operating practices, assessment of performance and qualification of data, identification of trouble and improvement of data quality, and design of auditing activities.[2]

A report assessed the potential use of beryllium in the construction of controlled nuclear reactors.[3]

[2]Wohlschlegel, P. S., F. Smith, and D. E. Wagoner. Guidelines for Development of a Quality Assurance Program: V. XI - Determination of Beryl Emissions From Stationary Sources, Environmental Monitoring and Support Laboratory. EPA-650/4-74-005-K, April 1976, 156 pp.

[3]Allison, G. S. Assessment of Materials, Needs for Fusion Reactors. Battelle Northwest Laboratories. July 1976, 5 pp.

Bismuth

By John A. Rathjen[1]

Domestic consumption and imports of bismuth in 1976 increased sharply over the totals reported in 1975, while both domestic production and exports declined during the year. Consumption rose to 2.4 million pounds, an increase of 71% above that of 1975. With the exception of other alloys, consumption in all categories increased and cumulatively was over 1 million pounds higher than that of 1975. Imports of bismuth were up 75% to 2.3 million pounds. Exports dropped to 68,488 pounds, a reduction of 60,405 pounds from those of 1975. This was attributed to reduced demand and low prices in the European market. The domestic price remained at $7.50 per pound throughout the year despite the apparent increase in demand in the United States. World bismuth mine production increased 5% to 9.26 million pounds. The general pattern of production was unchanged from the previous year.

Table 1.—Salient bismuth statistics

(Pounds)

	1972	1973	1974	1975	1976
United States:					
Consumption	2,315,534	2,906,219	2,283,978	1,406,021	2,410,584
Exports[1]	264,276	151,053	329,926	128,893	68,488
Imports, general	1,562,934	2,683,671	1,893,744	1,331,173	2,328,051
Price: New York, average per pound ton lots	$3.63	$4.92	$8.41	$7.72	$7.50
Stocks Dec. 31: Consumer	717,466	540,756	596,757	451,250	483,810
World: Production[2]	8,808,000	8,205,000	r10,631,000	r8,818,000	9,262,000

rRevised.
[1]Includes bismuth, bismuth alloys, and waste and scrap.
[2]Excludes the United States.

Legislation and Government Programs.—Government stocks of bismuth remained at 2,081,298 pounds. Broken down, the total included 567,186 pounds in the national stockpile and 1,514,112 pounds in the supplemental stockpile. On October 1, 1976, the Federal Preparedness Agency (FPA) set a new goal for bismuth of 771,000 pounds. This resulted in a surplus of 1,310,298 pounds, which would require congressional authorization for disposal. Bismuth remained on the list of commodities eligible for exploration assistance under the program administered by the Office of Minerals Exploration (OME). However, no funds were available in 1976 for exploration projects, and none have been requested since fiscal year 1974. The Tax Reform Act of 1969 provides a percentage depletion allowance of 22% for domestic production and 14% for U.S. companies producing from foreign sources.

[1]Mineral specialist, Division of Nonferrous Metals.

DOMESTIC PRODUCTION

Bismuth was produced almost entirely from the treatment of lead ores and bullion of both foreign and domestic origin. A single primary refinery operated by ASARCO, Inc. at Omaha, Nebr., accounted for some 99% of the primary U.S. production. A final shipment was made of primary metal from the lead refinery of UV Industries, Inc., at East Chicago, Ind. A small quantity of bismuth was also recovered by recycling secondary material at the United Refining and Smelting Co., Franklin Park, Ill. U.S. refinery production statistics are withheld to avoid disclosing company confidential data.

CONSUMPTION AND USES

Consumption of bismuth in the United States during 1976 was 2.4 million pounds, a rise of 1 million pounds over the quantity consumed in 1975. All consumption categories, with the exception of other alloys, showed increases. The largest increase occurred in the pharmaceutical sector, which consumed almost 1.4 million pounds, a gain of some 840,000 pounds compared with that of 1975. The major part of this growth was attributed to the use of bismuth in the industrial chemical area, where it functions as a catalyst in the manufacture of acrylonitrile. Use of bismuth in the metallurgical area also rose significantly, reflecting a general rise in the domestic economy. Bismuth consumption in cosmetics remained steady.

Table 2.—Bismuth metal consumed in the United States, by use

(Pounds)

Use	1975	1976
Fusible alloys	401,932	518,648
Metallurgical additives	416,200	455,940
Other alloys	26,007	20,263
Pharmaceuticals[1]	553,313	1,391,663
Experimental uses	713	8,756
Other uses	7,856	15,314
Total	1,406,021	2,410,584

[1]Includes industrial and laboratory chemicals and cosmetics.

STOCKS

Consumer stocks at yearend were 483,810 pounds, a rise of 32,560 pounds during the year. No data are available on producer or dealer stocks.

PRICES

The domestic producer price for refined bismuth was $7.50 per pound throughout the year. Dealer quotations rose to a range of $6.50-$6.80 per pound at the end of the first quarter but declined during the year, closing in December at $4.50-$4.80 per pound.

FOREIGN TRADE

Exports of bismuth in all forms dropped sharply for the second consecutive year to 68,488 pounds, a decline of 60,405 pounds from that of 1975. During 1976, bismuth was exported to 17 countries, of which 7 accounted for about 95% of total shipments. The principal countries receiving U.S. exports, in order of declining quantity, were

Italy 21,075 pounds, 31%; Canada, 16,503 pounds, 24%; the Netherlands, 8,722 pounds, 13%; the United Kingdom, 6,712 pounds, 10%; Spain, 5,758 pounds, 8%; Ireland, 3,348 pounds, 5%; and Belgium-Luxembourg, 2,754 pounds, 4%.

General imports of metallic bismuth in 1976 increased by about 997,000 pounds to 2.3 million pounds as compared with that of 1975. This large increase was attributed primarily to the general uptrend of the economy and reflected the very strong demand in the category of industrial chemicals. A total of 12 countries supplied the U.S. import requirements; 9 of these accounted for about 96% of the total. The principal suppliers were Peru, 24%; the United Kingdom, 13%; West Germany and Japan, 12% each; Mexico, 11%; the Republic of Korea, 8%; Belgium-Luxembourg, 7%; Chile (Bolivia) 5%; and Canada, 4%. Chile does not produce bismuth in any form; however, Bolivia has no seaport and Bolivian materials shipped to the United States via a Chilean port show the intermediate country as a port of origin.

Table 3.—U.S. exports of bismuth[1]

Year	Gross weight (pounds)	Value
1973	151,053	$446,284
1974	329,926	1,520,105
1975[2]	128,893	635,717
1976[2]	68,488	513,660

[1]Includes bismuth, bismuth alloys, and waste and scrap.
[2]Adjusted by the Bureau of Mines.

Table 4.—U.S. general imports of metallic bismuth, by country

Country	1975		1976	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Belgium-Luxembourg	84,944	$596	151,690	$790
Canada	51,143	409	100,983	612
Chile	--	--	107,364	694
France	22	(1)	--	--
Germany, West	102,290	802	288,028	2,152
India	--	--	55,000	299
Italy	--	--	2,203	12
Japan	190,962	1,256	278,995	1,634
Korea, Republic of	125,951	668	177,666	970
Mexico	161,834	955	248,120	1,509
Netherlands	4,349	23	--	--
Peru	140,630	1,177	569,078	3,261
United Kingdom	434,060	3,343	307,818	2,037
Yugoslavia	34,988	213	41,106	184
Total	1,331,173	9,442	2,328,051	14,154

[1]Less than 1/2 unit.

WORLD REVIEW

Although U.S. consumption recovered substantially during 1976, world production increased only slightly. This was attributed primarily to the decreased use for pharmaceuticals in France and the generally slow recovery of the European economy from the recession of 1975. All of the producing countries produced at levels similar to those in 1975.

Australia.—Mine production of bismuth in Australia rose nominally from 1.8 million pounds in 1975 to an estimated 1.9 million pounds in 1976. Production continued to be somewhat curtailed since copper mining by Peko-Wallsend Ltd. at Tennant Creek in the Northern Territory remained dormant. The main source of bismuth from Australia in 1976 was a gold-bismuth bullion which was shipped through northern Europe for gold recovery, with residue moved forward to the United Kingdom for bismuth recovery and refining. Minor amounts of bismuth were also shipped from Australia as byproducts in lead ores and concentrates; however, the bismuth assays were too low to be accountable for production purposes.

Bolivia.—Bolivia became the world's leading producer of refined bismuth in March with the inauguration of the new Corporación Minera de Bolivia (COMIBOL) refinery at Quechisla, Potosi. The refinery, with an annual estimated capacity of 13 million pounds, was built at a cost of $500,000 by the Belgian firm Sidech. Metal of 99.99% purity was shipped during the year. Bismuth is also shipped in the form of ores and concentrates by COMIBOL as well as by independent medium and small miners. Bolivia is one of the few countries in which bismuth is mined directly rather than as a byproduct.

Canada.—Bismuth metal was produced by two companies in Canada. The smelting division of Brunswick Mining & Smelting Corp. Ltd. produced metal at its Belledune plant near Bathurst, New Brunswick. The other principal metal producer was Cominco Ltd. at its lead-zinc plant in Trail, British Columbia. Most of the metal produced in Canada came from ores mined within the country, although small quantities were recovered from imported ores. Recent exploration in Charlotte County, New Brunswick, established a large reserve of a complex tungsten-bismuth-molybdenum ore. In some areas the bismuth assays have been established at 0.11% to 0.15% and could provide a considerable increase to world production.

Japan.—Production of bismuth metal in Japan during 1976 continued at about the same level as in 1975 totaling 1.5 million pounds at yearend.

Mexico.—Production of bismuth in Mexico during 1976 was about 1.3 million pounds, a substantial recovery from the relatively low 981,000 pounds in 1975. Two companies; Industrial Minera Mexico, S.A., and Met Mex Peñoles, S.A., continued as the producers of metal and bullion at their refineries, both of which are located in Monterrey, in the State of Nuevo Léon.

Peru.—Bismuth production in Peru continued at a steady level, totaling 1.4 million pounds during 1976. Metal was produced at the Oroya works, managed by Centromin-Peru, and marketed on a worldwide basis by Minero Peru Comercial.

Table 5.—Bismuth: World mine production, by country

(Thousand pounds)

Country[1]	1974	1975	1976[p]
Argentina (in ore)	(2)	e(2)	e(2)
Australia (in concentrates)	r2,579	1,882	e1,900
Bolivia	r 31,351	31,348	1,349
Canada	245	345	337
China, People's Republic of (in ore)[e]	550	550	550
France (metal)	r125	123	e132
Germany, West (in ore)[e]	22	23	23
Japan (metal)	1,837	1,480	1,501
Korea, Republic of (metal)	289	249	e265
Mexico[4]	1,583	981	e1,280
Mozambique[e]	9	9	--
Peru[4]	1,469	1,354	e1,400
Romania (in ore)[e]	180	180	180
Sweden (in ore)[e]	33	33	33
Uganda (in ore)[e]	9	9	10
U.S.S.R. (metal)[e]	130	130	130
United States	W	W	W
Yugoslavia	220	122	172
Total	r10,631	8,818	9,262

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data; not included in total.

[1]In addition to the countries listed, Brazil, Bulgaria, East Germany and the Territory of South-West Africa are believed to produce bismuth, but available information is inadequate for formulation of reliable estimates of output levels.

[2]Less than 1/2 unit.

[3]Production by COMIBOL plus exports by medium and small mines.

[4]Bismuth content of refined metal, bullion, and alloys produced indigenously, plus recoverable bismuth content of domestic ores and concentrates exported for processing.

Boron

By J. W. Pressler[1]

In 1976, U.S. production and consumption of boron minerals increased somewhat compared with that of 1975, however the total value of sales and captive uses increased to $185 million, the largest amount in history. Exports of boric acid increased slightly in 1976, while exports of refined sodium borate were unchanged. Production was maintained at near peak levels, and the three major producers had a steadily increasing market demand during the year.

Insulation fiberglass, textile fiberglass, and borosilicate glass products continued to be the principal uses for borate minerals and chemicals in the United States, consuming more than 50% of the total supply. During the year, a constantly increasing market for thermal insulation caused increased demands on borate minerals and chemicals in insulation fiberglass (glass wool) and on boric acid in the production of cellulosic insulation (paper wool).

California provided the entire U.S. output of boron minerals, mostly as sodium borates and boric acid but more recently with some calcium borates. Imports of calcium borate (colemanite) from Turkey in 1976 increased slightly over those of 1975.

Table 1.—Salient boron minerals and compounds in the United States

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
Sold or used by producers:					
Quantity:					
Gross weight	1,121	1,225	1,185	1,172	1,246
Boron oxide	607	664	619	603	630
Value	$95,882	$113,648	$128,306	$158,772	$184,852
Imports for consumption:[1]					
Quantity	20	18	21	28	30
Value	$626	$568	$852	$1,560	$1,953

[1]Colemanite only.

DOMESTIC PRODUCTION

Domestic production and sales of boron minerals increased 4% in 1976, compared with that of 1975. Most of the output continued to come from Kern County, Calif., and to a smaller extent from San Bernardino and Inyo Counties, Calif.

At Boron, in Kern County, the large open pit mine and refining plant belonging to U.S. Borax & Chemical Corp., a member of Rio Tinto-Zinc Corp., Ltd., of London, England, continued to be the world's chief source of boron, although Turkish tincal, colemanite, and refined products are rapidly becoming of great importance in world trade. U.S. Borax now processes over 10,000 tons of ore per day, producing principally crude sodium borate, refined sodium borate, and their anhydrous varieties at the Boron mine site. During the year, the $54 million expansion project at Boron continued on schedule; a major portion of the new capacity was to be onstream by 1977. This project will provide a 25% to 30% increase in the output of U.S. Borax's primary products,

[1]Physical scientist, Division of Nonmetallic Minerals.

pentahydrate and decahydrate borax. Considerable "debottlenecking" of the facilities was accomplished during the year, and design of additional facilities to further expand capacity was in progress. The company's chemical plant at Wilmington, Calif., produced a variety of high-quality specialty borate products and had a secondary function of serving as an overseas shipping point for bulk shipments. The rated capacity of the boric acid plant at Wilmington was increased 25% in 1976, and the spray-dry plant's capacity was tripled. The company's total production increased slightly during 1976. Demand for all industrial borax products increased steadily during the year. Economic recovery started later than might have been expected by reference to 1975, but by the latter part of 1976 sales were again at a very satisfactory level.

Boric acid was projected to have a strong growth rate for a large variety of end uses, including cellulose insulation and fire-resistant cotton batting, textile fiberglass, and heat-resistant glass, and U.S. Borax was giving serious consideration to additional boric acid capacity at yearend. At Burlington, Iowa, U.S. Borax has a plant and warehousing facility for compounding, packaging, and distributing household soaps and other consumer products to the Eastern and Midwestern United States. These combined operations of U.S. Borax in the United States had an annual capacity of more than 600,000 short tons of boric oxide (B_2O_3) equivalent (or about 190,000 tons of contained boron) in 1976 and will be 25% to 30% greater when the planned expansions are completed in 1977.

Crude commercial-grade sodium borates, known as Rasorite 46 (pentahydrate borax) and Rasorite 65, the anhydrous equivalent, represent almost one-half of U.S. Borax's output in tonnage and about one-half of the value. In addition to the Rasorite 46 and 65 production, refined borax pentahydrate and decahydrate represent over one-third of the output tonnage.

U.S. Borax maintains a warehouse and distribution facility at Botlek, Netherlands, from which borax and boron chemicals are shipped to other parts of Europe.

At Searles Lake, Kerr-McGee Corp. operated the Trona and Westend plants, with combined capacities of approximately 130,000 tons of B_2O_3 equivalent per year. Borates were produced along with potassium compounds, lithium carbonate, soda ash, and salt cake from the mineral-rich brines. The Westend plant had a capacity of 25,000 tons per year of B_2O_3 equivalent, principally as anhydrous borax. The flowsheet was based upon the carbonation process. At the nearby Trona plant, Kerr-McGee utilized the carbonation process and a differential evaporative process with a combined capacity of 100,000 equivalent tons of B_2O_3 per year to produce borax pentahydrate and decahydrate, boric acid, and anhydrous borax. Boric acid was also produced from weak brines by liquid-liquid extraction. A major new soda ash plant is being constructed adjacent to these existing facilities for completion by yearend 1977, but a borate cycle apparently is being deferred until the recovery economics are feasible.

In 1976, Tenneco Oil Co., the third U.S. producer, significantly increased production of colemanite and ulexite from its Ryan mine near Death Valley, Inyo County, Calif. The colemanite (calcium borate) is processed at a plant at Lathrop Wells, Nev., utilizing calcination and screening, principally for the fiberglass market. The ulexite (calcium-sodium borate) is trucked to a plant at Dunn, Calif., where it is prepared for the market by grinding to minus 200 mesh. Its principal use is in the manufacture of glass wool insulation and fire-retardant chemicals.

Tenneco had increased its reserves as a result of exploration and development and had approved a plan to double production within 3 years with a capital investment of $20 million. In October, however, Tenneco sold its total boron mining and marketing assets to the American Borate Corp., which will continue the present operations. This action followed the passage by Congress of Public Law 94-429 to regulate and constrain all mining activities within the National Park system. The law, which repealed the mineral entry provision for certain units, also applied to Death Valley National Monument, which is currently the sole commercial source of colemanite and ulexite in the United States.

CONSUMPTION AND USES

About 50% of the U.S. output of boron minerals and compounds was exported in 1976, while the balance was consumed domestically. Official U.S. trade statistics report only the export of refined boron chemical products; the export of crude sodium borate, equivalent to a commercial grade of 98% to 99% purity, is proprietary information. So-called "crude" product exports have never been reported by the Bureau of the Census, but probably will be, effective January 1, 1978. With these total figures, an accurate consumption figure will be available each year.

Measured in terms of boron content, U.S. consumption was probably about 112,000 short tons in 1976, compared with possibly 98,000 tons in 1975 and 110,000 tons in 1974. Insulating fiberglass, textile fiberglass, and borosilicate glasses were the major consuming uses for boron minerals and compounds in the United States in 1976, approaching 50% of the total end use. Spectacular growth for thermal insulation was reflected in increased demand for borates in insulation fiberglass manufacturing and in the production of cellulosic insulation. The production of "paper wool" from shredded scrap newsprint and boric acid created an unusually heavy demand for boric acid by yearend and may continue unabated for the near term.

About 80% of home insulation materials in 1976 was accounted for by glass fiber, produced by three companies in the United States. Dominant in the industry were Owens-Corning Fiberglas Corp. with about 50% of the market, and Johns-Manville Corp. and CertainTeed Corp., sharing the other 50%. However, 1976 saw the emergence and strong competition of cellulosic insulation, especially that produced by shredded newsprint with the addition of about 20% to 25% boric acid and borax for flame and fire retardancy. Small plants were promoted and financed by the Small Business Administration, surmounting the traditional industry entrance barriers of high capital cost, competitive technology, and industry expertise. By yearend, shortages of boric acid had developed which caused sales allocations and black market activities.

Up to 11,000 tons of boron content was used in 1976 in the rapidly growing cellulosic insulation business, consuming up to 25% of the weight of the insulation in formulations of boric acid and sodium borate and other chemicals. A recent survey of this market indicated a growth rate of 34% for the next 3 years.

In addition to the thermal insulation markets, applications for borates currently experiencing significant growth included the treatment of mattresses and upholstery with boric acid for fire retardance and the incorporation of borate compounds in plastics for similar purposes.

U.S. consumption in 1976 of borate compounds in cleaning and bleaching was about 17,000 tons of boron content, including about 6,000 tons in sodium perborate detergents for higher temperature washing. Perborates were also used as a bleaching agent or as a source of active oxygen in laundry products. In addition, chemical derivatives require at least another 10,000 tons per year of boron content. Borohydrides have a growing use as chemical reductants in such important industrial processes as regenerating sodium hydrosulfite in reductive pulp bleaching. Borax and boric acid uses in the cleansing field included toothpaste, mouthwash, and eyewash. Approximately 8,000 tons of boron yearly was used in the manufacture of biological and growth-control chemicals for use in algicides and water treatment, fertilizers, herbicides, and insecticides.

Two minor but important uses, as corrosion inhibitors in antifreeze and as fire retardants, consumed as much as 5,000 tons of boron content per year. The use of fire-retardant chemicals such as zinc borate in the plastics industry enjoyed a very rapid growth in this market.

The list of miscellaneous uses is very diverse: Borates as fluxing material and as shielding slag in the nonferrous metallurgical industry; borate compounds as components in plating baths in the electroplating industry; ferroboron in small amounts in specialty steels; boron in nonferrous alloys such as surfacing metal that are subject to heavy wear; boron nitride compounds as abrasives; boric acid as a catalyst in air oxidation of hydrocarbons to key nylon intermediates, in the oxidation of paraffins to higher alcohols used as intermediates for surfactants, and as a conditioning agent in the manufacture of ammonium nitrate; and various boron products used in pharmaceuticals, paper, textile, leather, nuclear shielding, photography, paints and varnishes, adhesives, and pyrotechnics, and in a few commercial automotive fuels as boron esters to inhibit surface ignition and spark plug fouling.

U.S. demand for boron minerals and compounds is expected to increase substantially in view of the strong growth projected for a large variety of end uses, including textile fiberglass, heat-resistant glass, cellulosic insulation, and fire-resistant cotton batting.

PRICES

U.S. boron mineral and chemical prices, which were unchanged in 1975, were raised at least 12% (depending upon the product) at the beginning of 1976. The average value of 1976 borate mineral shipments was $293 per ton of B_2O_3, compared with $268 in 1975. As a result of general inflationary pressure plus the continued sharply rising cost of energy for industrial purposes in California, a further rise of around 7% was announced at yearend to take effect in early 1977. The rounded dollar figures quoted in table 2 are for U.S. f.o.b. plant prices per short ton of product.

Table 2.—Borate prices per short ton, 1976[1]

Product	Dec. 31, 1976
Borax, technical, anhydrous, 99%, bulk, works	$203-$248
Borax, technical, pentahydrate, 99-1/2%, bulk, works	105- 110
Borax, technical, decahydrate, 99-1/2%, bulk, works	82- 91
Boric acid, technical, 99.9%, bulk, works	202- 227
Boric acid, anhydrous, 96.0% B_2O_3, bulk, works	[2]538
Colemanite, American Borate Corp., calcined and screened, minus 70 mesh, 47% B_2O_3, f.o.b. railcars, Dunn, Calif.	[3]184
Colemanite, Turkish, 42% B_2O_3, crude, lump, f.o.b. railcars, U.S. east coast port	[4]134

[1]Chemical Marketing Reporter. V. 211, No. 1, Jan. 3, 1977, p. 52. Other conditions of final preparation, transportation, quantities, and qualities are subject to negotiation and somewhat different price quotations.
[2]U.S. Borax & Chemical Corp.
[3]American Borate Corp.
[4]Phillips Bros.

FOREIGN TRADE

U.S. exports of boric acid increased to 36,492 tons valued at $12.4 million in 1976, compared with 33,697 tons valued at $11.5 million in 1975. Exports of refined sodium borate showed a small decrease—to 211,362 tons valued at $49.2 million in 1976, from 212,266 tons valued at $42.5 million in 1975. In addition, a large amount of crude sodium borate (mostly Rasorite 46 with a B_2O_3 content of 48%) was exported and not reported in U.S. trade statistics. However, beginning in 1978, it will be reported as part of the official U.S. trade statistics. Exports of crude sodium borates remained the same compared with 1975.

A detailed breakdown of reported exports in 1975 is shown in table 3. Within this table, data for all countries outside Western Europe are fairly accurate. The aberration of high exports of refined sodium borates to the Netherlands continued in 1976, explained by the fact that the Netherlands is a major transshipment point rather than the final destination. A more meaningful tabulation of consuming nations, including the exports of crude borates, would show that West Germany, France, the United Kingdom, Belgium, and Italy were ahead of the Netherlands in that order.

In 1976, the United States imported 30,247 short tons of commercial-grade colemanite (calcium borate) valued at $1,953,000, all from Turkey. It was used principally for insulation fiberglass manufacturing. This compared with 27,641 short tons valued at $1,560,000 in 1975. Enamels and cleaning compounds were the principal borate markets in Europe. Sodium perborate was very effective as a detergent and bleaching agent because of the higher washing temperatures commonly used. This end use accounted for almost one-third of the total European borate consumption, but only about 5% of U.S. consumption.

Table 3.—U.S. exports of boric acid and sodium borates, in 1976

Destination	Boric acid (H_3BO_3 content) Quantity (short tons)	Boric acid (H_3BO_3 content) Value (thousands)	Sodium borates (refined) Quantity (short tons)	Sodium borates (refined) Value (thousands)
Australia	3,715	$1,221	8,526	$1,798
Belgium-Luxembourg	34	8	--	--
Brazil	3,090	1,308	8,502	1,959
Canada	2,648	672	36,492	5,666
Chile	--	--	546	81
Colombia	515	187	1,003	191
Costa Rica	21	9	284	67
Cyprus	--	--	83	11
Denmark	48	12	--	--
El Salvador	4	2	240	90
Finland	4	2	211	46
France	272	86	110	42
Germany, West	535	144	55	30
Greece	--	--	84	11
Guatemala	10	5	66	21
Hong Kong	180	47	3,406	877
Indonesia	61	24	1,047	185
Iran	1	2	2,078	237
Israel	140	47	305	69
Italy	1,301	313	168	22
Japan	10,992	3,721	41,980	9,969
Korea, Republic of	1,229	454	4,513	651
Malagasy Republic	--	--	55	8
Malaysia	9	4	293	51
Mexico	3,574	1,097	21,457	3,679
Netherlands	4,189	1,609	43,862	14,008
New Guinea	90	32	--	--
New Zealand	374	133	3,075	1,006
Nicaragua	--	--	124	47
Norway	183	41	--	--
Pakistan	200	84	212	34
Peru	112	43	185	33
Philippines	580	189	1,150	287
Portugal	--	--	62	7
Singapore	218	65	350	55
South Africa, Republic of	616	171	1,049	272
Spain	117	61	--	--
Sweden	258	66	493	68
Switzerland	--	--	118	16
Taiwan	379	199	3,514	647
Thailand	92	38	744	148
United Arab Emirates	--	--	72	7
United Kingdom	389	149	23,183	6,354
Uruguay	89	28	144	43
Venezuela	110	46	1,318	317
Other	113	44	203	46
Total	36,492	12,363	211,362	49,156

WORLD REVIEW

Argentina.—Argentina remained the only known producer of boron minerals in South America in 1976, maintaining a borate minerals output of 86,000 short tons. Boroquimica, an RTZ Borax Ltd. subsidiary, produced the major portion of the output from its Tincalayu mine in the Salar del Hombre Muerto basin in the Salta region of northwest Argentina. A small production also came from the Compañía Productora de Boratos. Most of the output was consumed domestically, with some exports to other countries in the Latin America Free Trade Area. In 1976, 24,208 short tons of sodium and calcium borates was reportedly exported to Brazil. The production and export of calcium borate in this case indicated that the Salar de Pastos Grandes deposit near the Tincalayu mine may also be in operation.[2]

Bolivia.—Although there was no current production, it was known that there were large deposits of sodium carbonate, ulexite, and borax associated with the Salara de Uyuni and Coipasa as well as other smaller saltpans on the Altiplano. The most important deposit appeared to be located just south of the Salara de Uyuni.[3]

[2]Bank of London and South America Review. March 1977, p. 136
Kistler, R. B., and W. C. Smith. Boron and Borates. Ch. in Industrial Minerals and Rocks, 4th ed., A.I.M.E., New York, 1975. p. 487.
[3]U.S. Embassy, La Paz, Bolivia. State Department Airgram A-38, Apr. 29, 1977, p. 61.

Chile.—Production of ulexite from Ascotan and boric acid from the refinery at Coya Sur was being phased out. In 1974 there was a small production of 1,100 tons, and no production was reported in 1975. In 1976, it was reported that only 3.5 short tons of ulexite with a 31% B_2O_3 content was produced.[4]

China, People's Republic of.—The People's Republic of China produced a sufficient but relatively unknown amount of borate minerals, and little is known about the industry. A decade ago, it was reported that a borax plant with hundreds of furnaces was built at Iksaydam, which is a 15-square-mile salt lake near Chaha in Tsinghai Province in northwest China at an elevation of over 10,000 feet. This lake is also a major salt producer, and the borax is a byproduct of the brine refining.[5]

A comprehensive survey in 1976 by Chinese scientific workers on the Chinghai-Tibet plateau established that Tibet had almost 1,000 lakes, most of which are brackish or salt, and with abundant borax content in many of the lakes in northern Tibet.[6]

Small shipments of approximately 430 short tons of borate minerals were exported to Japan in 1976, while 100 tons of refined products, mostly borates and perborates, were imported from Japan.

France and Spain.—Increased boric acid refining capacity was completed during 1976 at the plants of RTZ Borax Ltd. in France and Spain, and the new installations were reported as operating satisfactorily.[7]

Germany, East.—Small quantities of borates were recovered during potash mining and processing operations in the Strassfurt area. It is estimated that 4,200 tons of processed borax decahydrate was produced in 1976 and similar amounts in 1974 and 1975.

Other South America.—There are over 40 borate deposits in the high Andes along a 550-mile stretch of the common borders of Argentina, Bolivia, Chile, and Peru. This tectonic-volcanic belt has many closed basins with playas or salt flats, called salares. Resources are large, but any figures lack supporting data. Prior to 1950, Chile was an important producer of ulexite for the world market, and Peru exported ulexite from 1894 until the 1920's. Almost all production from South America at present is from the Salta Province of Argentina.[8]

Turkey.—The Turkish third 5-year plan (1973-77) and other programs have emphasized the importance of the mining sector to the growth of the Turkish economy. This is true even though mineral production accounts for only about 1.5% of the gross national product and for about 8% of the combined value-added in manufacturing and mining. Mineral exports, led by chromite, borates, and magnesite, contributed $130 million, or 6.5% of overall export earnings, in 1976. A continuing recommendation of the 1977 Annual Program, released by the Government on December 1, 1976, was the nationalization of boron minerals, effectively limiting exploitation to the public sector. Pragmatically, this was already a fait accompli, as Etibank apparently controlled 98.5% of the reserves and produced over 60% of the 1976 production.[9]

Production of borate minerals in Turkey in 1976 was 1,005,000 short tons of 27% to 46% B_2O_3 content, as provisionally reported by the Turkish State Institute of Statistics, Mineral Division. This was about 5% less compared with 1975. The boron mineral industry, dominated by the mines, washing concentrators, and refineries of Etibank (the Turkish Government mining corporation responsible for all State mining activities), continued its production at about the same rate in 1976 as 1975. Sales were not as high as expected, but towards yearend new orders increased rapidly.

Installation of the new 110,000-ton-per-year boric acid plant at the port city of Bandirma was proceeding on schedule. Tenders for equipment went out at yearend, and completion was scheduled for 1979. Total investment cost was estimated at approximately $19 million, with escalation considerations.[10]

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[4]U.S. Embassy, Santiago, Chile. State Department Airgram A-67, May 9, 1977, p. 4 of enclosure.

[5]Wang, K. P. The People's Republic of China, A New Industrial Power With a Strong Mineral Base. BuMines Spec. Publ., 1975, p. 89.

[6]British Broadcasting Corp. Summary of World Broadcasts. May 11, 1977, p. 8.

[7]The Rio Tinto-Zinc Corp. Ltd. (London). Annual Report and Accounts. 1976, p. 33.

[8]Pages 486-488 of second work cited in footnote 2.

[9]U.S. Embassy, Ankara, Turkey. State Department Airgram A-11, Feb. 4, 1977, pp. 2-4.

[10]Chemical Age. V. 113, No. 2988, Oct. 22, 1976, p. 3.

Etibank's large boron chemical complex planned for the Kirka area has been plagued with delays and cost increases. The facilities, with a planned capacity of over 284,000 tons of boron products per year, were originally scheduled for completion in 1973 at a cost of $2 million. In 1976, completion was scheduled for 1979 at a cost of $69 million.[11]

U.S.S.R.—In 1976, Japan reported imports of 4,079 short tons of crude borates from the U.S.S.R., 2,686 short tons of boric acid, 29 short tons of boric oxide, and 440 short tons of other sodium borates. These were increases compared with those of 1975. Only minor amounts of Japanese borate chemical exports to the U.S.S.R. were noted.

TECHNOLOGY

In one important area of research U.S. Borax & Chemical Corp. received a British patent (No. 1,465,299) on the froth flotation recovery of clean crystalline boric acid from a hot slurry obtained by treating borate minerals or compounds with sulfuric acid. By this patented process, the warm-to-hot acid slurry is treated with a salt of a polymeric carboxylic acid as a crystal modifier and with an anionic silicone as a froth modifier. The treated slurry is then cooled, and subjected to flotation to obtain a froth concentrate of crystalline boric acid containing substantially no clay slime or sodium sulfate. The industry awaited the commercial feasibility of this technique, which holds considerable promise for the treatment of low-grade and off-grade ores.

Fiberglass-reinforced plastic storage tanks developed into one of the fastest growing tank materials for the storage of petroleum and chemical products. Corrosion resistance and lightweight characteristics made installation faster, easier, and more economical.

The use of alkali-resistant glass-fiber-reinforced cement for cladding panels, retaining walls, and acoustical hoods resulted in a new construction material which is strong, relatively lightweight, and very versatile. It is also noncombustible and flexible and has a high impact resistance.[12]

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[11]Economic Press Agency. Weekly Special Report. Jan. 17, 1977, p. 5.

[12]Chemical Marketing Reporter. Fiber Glass Tanks Gaining. V. 210, No. 18, Nov. 1, 1976, pp. 7, 26.

Engineering News-Record. Glass Reinforced Cement. Aug. 5, 1976, p. 2.

Engineering News-Record. Glass Fibers Cut Weight of Wall Panels. Dec. 9, 1976, p. 28.

Bromine

By Russell J. Foster[1]

The amount of elemental bromine sold or used by domestic producers in 1976 increased 8% to an alltime high of nearly 440 million pounds owing to greater demand for ethylene dibromide and flame-retardant compounds. The total value of bromine and bromine compounds sold by producers was $206 million.

Arkansas continued as the dominant site of the industry. During the year four bromine producers located in Arkansas either expanded capacity or were constructing new facilities for the manufacture of bromine-related products. Another producer announced plans to shift bromine operations from Michigan to its plant in Arkansas within 2 years.

The authority of the Environmental Protection Agency (EPA) to regulate the lead content of gasoline was upheld by the courts, signaling what should be reduced demand in the future for ethylene dibromide as an additive for leaded gasoline. EPA also questioned the use of ethylene dibromide as a pesticide. The possibility of harmful effects on those exposed to high concentrations of the flame-retardant polybrominated biphenyl was being evaluated in Michigan. Another flame-retardant, tris(2,3-dibromopropyl)phosphate, was named as a possible carcinogen.

DOMESTIC PRODUCTION

The quantity of domestic elemental bromine sold or used increased 8% in 1976 to a record level of 439,538,000 pounds. Sales of bromine compounds by producers climbed 7%. After 2 years of decline, ethylene dibromide sales showed an 8% gain in 1976. The amount of methyl bromide sold rose less than 1%, but other bromine compounds sales, including flame-retardants, increased 6%. The total value of bromine compounds and elemental bromine rose nearly $5.8 million. This can be attributed solely to greater production, because the unit value of elemental bromine and the average price of manufactured compounds both declined.

There were nine bromine-producing plants operated in two States by six companies. Three of these companies combined produced 83% of the U.S. output. The State of Arkansas maintained its position as the Nation's principal source of bromine, but, the State-appointed Brine Study Commission continued to evaluate problems related to health, the environment, and royalty payments to local landowners.

The Great Lakes Chemical Corp. brought a new bromine plant onstream at Marysville, Ark., in February 1976. The cost of the facility was more than $10 million.[2] Great Lakes and Produits Chimiques Ugine Kuhlmann of France agreed to form a jointly owned company, Forex Chemical Corp., in the United States to manufacture and market brominated fire-extinguishing compounds.[3]

Michigan Chemical Corp. announced plans to phase out the operations of its St. Louis, Mich., plant during the next 2 years. By September 1978, bromine-based operations will be shifted to the El Dorado, Ark. plant, where construction was begun on a

[1]Physical scientist, Division of Nonmetallic Minerals.
[2]Andre, H. W. News Release by Great Lakes Chemical Corp. Feb. 20, 1976, 2 pp.
[3]Chemical Marketing Reporter. Great Lakes, PCUK Form Bromine Venture. V. 209, No. 6, Feb. 9, 1976, p. 3.

$9 million, multimillion pound, flame-retardant-products complex. Completion of the unit was scheduled for early 1977.[4] Michigan Chemical and Velsicol Chemical Corp., both subsidiaries of Northwest Industries, Inc., agreed to a merger effective January 1, 1977.[5]

The Dow Chemical Co. revealed a plan to quadruple production capacity for calcium bromide at its Midland, Mich., plant by 1977.[6] Dow closed its ethylene dibromide unit at Midland in July 1976, diverting the bromine to the manufacture of other bromine compounds.[7] The company continued ethylene dibromide production at its plant in Magnolia, Ark., where bromine capacity was increased in 1976.

Ethyl Corp. initiated a $15 million expansion of its plant at Magnolia, Ark. The first of two new units was completed in the fall of 1976 for the manufacture of an agricultural chemical intermediate. The second facility, slated for startup in early 1977, will produce alkyldimethylamines. Both operations will utilize bromine chemistry for the production of these materials.[8]

[4]Chemical Marketing Reporter. Michigan Chemical Slates Shutdown of Operation. V. 210, No. 7, Aug. 16, 1976, p. 3.

———.Flame Retardants Unit Going Up in Arkansas for Michigan Chemical. V. 209, No. 16, Apr. 19, 1976, pp. 5, 22.

[5]Chemical and Engineering News. Concentrates. Industry/Business. V. 54, No. 46, Nov. 8, 1976, p. 9.

[6]Chemical and Engineering News. Checkoff. New Plants. V. 54, No. 35, Aug. 23, 1976, p. 15.

[7]Chemical and Engineering News. Concentrates. Industry/Business. V. 54, No. 35, Aug. 23, 1976, p. 9.

[8]Chemical Marketing Reporter. Ethyl Corp. Expanding Bromine Chemical Units. V. 209, No. 13, Mar. 29, 1976, pp. 3, 24.

Table 1.—Elemental bromine sold as such or used in the preparation of bromine compounds by primary producers in the United States

(Thousand pounds and thousand dollars)

	1975		1976	
	Quantity	Value	Quantity	Value
Sold	57,410	15,871	55,847	13,246
Used	349,753	97,255	383,691	94,407
Total	407,163	113,126	439,538	107,653

Table 2.—Bromine compounds sold by primary producers in the United States

(Thousand pounds and thousand dollars)

	1975			1976		
	Quantity		Value	Quantity		Value
	Gross weight	Bromine content		Gross weight	Bromine content	
Ethylene dibromide	267,523	227,582	69,806	288,663	245,565	74,660
Methyl bromide	24,161	20,336	10,618	24,374	20,516	10,891
Other compounds[1]	124,151	88,611	103,487	131,905	96,100	106,745
Total[2]	415,835	336,529	183,912	444,942	362,182	192,296

[1]Includes hydrobromic acid, tetrabromobisphenol-A, ethyl, ammonium, sodium, potassium, and other bromides.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—Bromine-producing plants in the United States

State and company	County	Plant	Production source
Arkansas:			
Arkansas Chemicals, Inc	Union	El Dorado	Well brines.
Ethyl Corp	Columbia	Magnolia	Do.
The Dow Chemical Co	do	do	Do.
The Great Lakes Chemical Corp	Union	El Dorado	Do.
do	do	Marysville	Do.
Michigan Chemical Corp	do	El Dorado	Do.
Michigan:			
The Dow Chemical Co	Mason	Ludington	Do.
do	Midland	Midland	Do.
Morton Chemical Co	Manistee	Manistee	Do.

CONSUMPTION AND USES

Demand for ethylene dibromide as a lead-scavenging additive in leaded gasoline increased in conjunction with higher gasoline consumption in 1976. Due to greater production of other bromine compounds, ethylene dibromide's share of bromine sold or used by producers remained at 56%.

The lengthy court battle over the EPA phasedown of lead in gasoline reached a conclusion. The suit brought by Ethyl Corp. and others against EPA initially received a favorable decision in December 1974 when a U.S. Court of Appeals ruled that EPA failed to prove its contention that lead emissions from auto exhausts were a significant health hazard. In March 1976, the same court vacated that judgment, permitting EPA to proceed with the phasedown. In June, the U.S. Supreme Court refused to hear the industry appeal, and EPA announced that enforcement would begin October 1, 1976. However, in late September, EPA delayed full implementation of the regulations. The 1976 and 1977 standards of 1.4 grams per gallon and 1.0 grams per gallon respectively, were deleted, and the 0.8 gram per gallon level effective January 1, 1978, would be suspended if the individual refining company could show that it had taken action toward procuring and installing the equipment needed to insure achievement of the final 0.5 gram per gallon standard by October 1, 1979. EPA felt that the original timetable would have imposed lead limits before refiners could install the equipment necessary to reach them, thus causing possible gasoline shortages in the summers of 1977 and 1978. A smaller, secondary use for ethylene dibromide, that of soil and space fumigation, was threatened when EPA listed it among pesticides that may be too dangerous to use.[9]

Consumption of methyl bromide, also used as an agricultural fumigant, was up only slightly in 1976 after a sharp increase in demand during 1975. Methyl bromide accounted for less than 5% of bromine sold or used.

Increased demand for other bromine compounds, which consumed 22% of the bromine sold or used, was paced by flame-retardants. The market for these chemicals has expanded dramatically owing to government flammability legislation.[10]

In March 1976, the Environmental Defense Fund claimed that tris(2,3-dibromopropyl)phosphate, a flame-retardant used in textiles including children's sleepwear, may cause cancer.[11] Results of extensive, long-term feeding studies with rats and mice at the National Cancer Institute were expected in early 1977. Tris was shown to be mutagenic by the Ames test, which has demonstrated a high correlation between mutagenicity and carcinogenic potential.[12]

A medical team from New York investigated the health of more than 1,000 people who had been exposed to high levels of polybrominated biphenyl in Michigan.[13] In 1973, this fire retardant was inadvertently substituted for a magnesium-oxide animal-feed supplement in Michigan, and thus was introduced into the food chain. Preliminary findings showed that approximately one-third of the group examined have suffered some ill effects, presumably caused by the chemical.[14]

The amount of elemental bromine sold as such to nonproducers declined 3% and accounted for nearly 13% of total bromine sold or used. Elemental bromine was utilized in water treatment, oxidation, and in the manufacture of bromine compounds.

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[9]Chemical and Engineering News. EPA Lists Pesticides That May Be Too Dangerous to Use. V. 54, No. 25, June 14, 1976, p. 18.

[10]Chemical and Engineering News. Government Rules: Problems, Opportunities. V. 54, No. 12, Mar. 22, 1976, pp. 12, 13.

Chemical Week. New Flame Rules Will Fire Up Retardant Sales. V. 119, No. 16, Oct. 20, 1976, p. 35.

[11]Chemical and Engineering News. Flame Retardant for Children's Sleepwear May Pose Cancer Risk. V. 118, No. 13, Mar. 31, 1976, p. 10.

[12]Blum, A., and B. N. Ames. Flame-Retardant Additives As Possible Cancer Hazards. Science. V. 195, No. 4273, Jan. 7, 1977, pp. 17-23.

Prival, M. J., E. C. McCoy, B. Gutter, and H. S. Rosenkranz. Tris(2,3-Dibromopropyl)Phosphate: Mutagenicity of a Widely Used Flame Retardant. Science. V. 195, No. 4273, Jan. 7, 1977, pp. 76-78.

[13]Chemical Marketing Reporter. PBB Poisoning Survey Is Carried Out by Environmental Health Unit in Michigan. V. 210, No. 20, Nov. 15, 1976, pp. 5, 43.

[14]Chemical Week. PBB the Villain? V. 120, No. 2, Jan. 12, 1977, p. 19.

PRICES

The average price, f.o.b. plant, of bulk elemental bromine as reported by producers in 1976 was 23.72 cents per pound, down 14% from the 1975 average price of 27.65 cents per pound. Quoted prices for bromine and selected compounds remained unchanged during 1976.

Product	Value per pound (cents)
Bromine, purified:	
Carlots, truckloads, delivered	75
Drums, carlots, truckloads, delivered east of the Rocky Mountains	55-62
Zone I:[1] Bulk tank car, tank trucks (45,000-pound minimum), delivered	25-30
Ammonium bromide, national formulary (N.F.), granular, drums, carlots, truckload, freight equalized	74
Bromochloromethane, drums, carlots, freight equalized	73
Tanks, same basis	71
Ethyl bromide, technical, 98%, drums, carlots, freight allowed, East	61.5
Ethylene dibromide, drums, carlots, freight equalized	37
Methyl bromide, distilled, tanks, 140,000-pound minimum, freight allowed	41
Potassium bromate, granular, powdered, 200-pound drums, carlots, f.o.b.	106
Potassium bromide, N.F., granular, drums, carlots, f.o.b.	67
Sodium bromide, 99% granular, 400-pound drums, freight, f.o.b.	65

[1]Delivered prices for drums and bulk shipped west of the Rockies, 1 cent per pound higher. Bulk truck prices 1 cent per pound higher for 30,000-pound minimum and 2 cents per pound higher for 15,000-pound minimum. Price f.o.b. Midland and Ludington, Mich., freight equalized, 1 cent per pound lower.

Source: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 210, No. 26, Dec. 27, 1976, pp. 30-42.

FOREIGN TRADE

Exports of elemental bromine and bromine contained in compounds increased 3% in 1976 to 67 million pounds and represented 15% of domestic bromine production. The amount of exported bromine compounds increased 2% while elemental bromine exports rose 22%. The value of total bromine exports increased 13%.

Imports of bromine amounted to less than 0.1% of domestic consumption. Approximately 73% of the bromine imported by the United States came from Israel.

Table 4.—U.S. exports of bromine and bromine compounds

(Thousand pounds and thousand dollars)

Year	Elemental bromine		Bromine compounds		
	Quantity	Value	Gross weight	Contained bromine	Value
1974	918	260	82,082	68,427	24,195
1975	3,635	1,037	72,395	61,598	25,791
1976	4,435	944	74,063	62,589	29,244

WORLD REVIEW

Israel.—Dead Sea Bromine Co., Ltd., announced plans to construct a 7,500-ton-per-year bromine-derivatives plant at Terneuzen in the Netherlands at a cost of $12 million. An Israeli trade agreement with the European Economic Community included reduction and eventual elimination of certain tariffs.[15] The company also planned to increase bromine production capacity to 55,000 tons per year by yearend 1978. The Biersheeba-based Bromine Compounds,[16] a sister company of Dead Sea Bromine Co.,

[15]Industrial Minerals. Bromine and Phosphate for Europe. No. 102, March 1976, p. 10.

[16]U.S. Embassy, Tel Aviv, Israel. State Department Airgram, A-192, Sept. 24, 1976, 6 pp., enclosure.

Ltd., was constructing a new plant at Ramat Hovev to process 44,000 tons per year of bromine.

Japan.—Toyo Soda Manufacturing Co. completed a 660-ton-per-year unit at its Nanyo plant for production of decabromodiphenyl ether, a flame-retardant additive for plastics. The expansion was facilitated by partial modification of an existing bromine-based agricultural chemical unit. Demand for the product increased due to more stringent U.S. flammability regulations concerning plastics used in electric household appliances.[17]

Asahi Glass Co. started up a plant to produce 500 tons per year of bromine-based flame-retardants at Kita-Kyushu.[18]

Poland.—The Geological Institute of Warsaw has established that the bromine content of underground waters in the Lower Silesia and the Wielhopolska areas is 36 million tons.[19]

United Kingdom.—The bromine flame-retardants section of Steetley Co.'s Stratford plant in London was closed. Expected legislation covering the flammability of certain materials had not yet been introduced in Parliament.[20]

Table 5.—Bromine: World production, by country

(Thousand pounds)

Country[1]	1974	1975	1976[p]
France	35,009	36,971	[e]37,500
Germany, West	11,581	9,414	9,158
India[e]	600	600	600
Israel	39,683	39,700	46,100
Italy[e]	[r]3,090	[r]2,200	2,650
Japan[e]	25,100	24,900	25,400
Spain	926	838	[e]880
U.S.S.R.[e]	28,000	28,000	30,000
United Kingdom	59,966	[e]62,000	[e]62,000
United States	432,094	407,163	439,538
Total	636,049	611,786	653,826

[e]Estimate. [p]Preliminary. [r]Revised.
[1]In addition to the countries listed, several other nations produce bromine, but output data are not reported, and available general information is inadequate for formulation of reliable estimates of output levels.

TECHNOLOGY

Gould, Inc., of Chicago and the Electronic Power Research Institute, Palo Alto, Calif., signed an 18-month, $274,000 contract to develop and assess the economic and technical feasibility of using a zinc-bromine storage battery to serve as an electric utility load-leveling device. Load levelers are used to store power generated during early morning hours for use during peak demand periods later in the day.[21]

Calcium bromide gained increased acceptance as a completion fluid in high-pressure oil and gas wells. Production capacity of the high-density, solids-free solutions expanded dramatically in 1976.[22]

Bromine chloride for cooling water treatment in power generation facilities was undergoing advanced field evaluation.[23]

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[17]Chemical Marketing Reporter. Toyo Soda to Increase Bromine Additive Facility. V. 210, No. 12, Sept. 20, 1976, p. 45.

Chemical Age. Toyo Completes Flame Retardant Plant. V. 113, No. 2982, Sept. 10, 1976, p. 2.

[18]Industrial Minerals. Company News & Mineral Notes. No. 107, August 1976, p. 50.

[19]Industrial Minerals. Company News & Mineral Notes. No. 108, September 1976, p. 55.

[20]Work cited in footnote 19.

[21]American Metal Market. Gould, Research Unit in Pact To Study Zinc-Bromine Battery. V. 83, No. 150, Aug. 2, 1976, p. 28.

[22]Work cited in footnote 6.

[23]Kampen, E., Progress Report from Great Lakes Chemical Corp. July 30, 1976, 2 pp.

Cadmium

By Ronald J. DeFilippo[1]

In 1976 cadmium metal production in the United States declined for the fourth consecutive year as output fell to the lowest level since 1936. Apparent consumption returned to a median level from the low level of 1975. Imported cadmium metal, not including the cadmium content of imported flue dusts and zinc concentrates, provided 42% of the total U.S. supply, compared with 41% in 1975.

Seven plants and six companies accounted for the total domestic primary production. Canada was the major source of zinc concentrates from which cadmium was extracted as a byproduct. The producer price increased from $2 per pound at the beginning of the year to $3 at yearend.

Legislation and Government Programs.—In March, 63 tons of cadmium metal was sold by the General Services Administration (GSA) from national stockpile excesses. On October 1 the Federal Preparedness Agency recommended a new stockpile goal of 12,351 tons. The yearend uncommitted inventory of cadmium was 3,164 tons.

The Office of Minerals Exploration is authorized to loan up to 50% of approved exploration costs for cadmium. However, no new funds were available in 1976 for exploration contracts. Depletion allowances were 22% for domestic mines and 14% for mines in foreign countries.

The National Institute for Occupational Safety and Health (NIOSH) was developing new criteria for cadmium exposure in the workplace. Previous standards limited dust exposure to 200 micrograms per cubic meter and fume exposure to 100 micrograms over an 8-hour day. The new recommended standard proposed in August 1976 was that workers should not be exposed to more than 40 micrograms of cadmium per cubic meter on a time-weighted average up to a 10-hour day, 40-hour week, or to more than 200 micrograms per cubic meter for any 15-minute sampling period.

Late in the year, the Environmental Protection Agency (EPA) suspended its plating effluent regulations, which required that platers meet best practical technology

[1]Physical scientist, formerly of the Division of Nonferrous Metals, present specialist is John Lucas, physical scientist.

Table 1.—Salient cadmium statistics

(Short tons)

	1972	1973	1974	1975	1976
United States:					
Production[1]	4,145	3,751	3,333	2,193	2,256
Shipments by producers[2]	5,240	4,304	3,250	818	2,562
Value ... thousands	$18,965	$23,891	$21,405	r$4,166	$10,498
Exports	509	153	31	198	252
Imports for consumption, metal	1,211	1,948	1,985	2,618	3,411
Apparent consumption	6,313	6,267	6,050	r3,368	5,932
Price: Average per pound[3]	$2.56	$3.64	$4.09	$3.36	$2.66
World: Production	18,371	18,925	r19,041	r16,925	18,892

rRevised.

[1]Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.

[2]Includes metal consumed at producer plants.

[3]Average quoted price for cadmium sticks and balls in lots of 1 to 5 tons.

standards by July 1977. Most platers were already covered by discharge permits that allowed them to exceed the standards while treatment facilities were being designed and installed. EPA expected to have new, less stringent regulations by mid-1977.

DOMESTIC PRODUCTION

Domestic cadmium metal production was 439 tons in the first quarter, decreased to 434 tons in the second quarter, peaked at 491 tons in the third quarter, and then declined in the fourth quarter to 470 tons. Total cadmium metal production for the year was 2,256 tons, up 3% from that of 1975. The New Jersey Zinc Co. cadmium plant was producing only part of the year, and production of cadmium began at midyear from National Zinc Co.'s new plant. Metal shipments were 40% greater than metal production and were over three times greater than those of 1975.

Smelter production of cadmium metal in the United States averaged about 7 pounds of cadmium per ton of slab zinc produced, compared with 10 pounds in 1975, 12 pounds in 1974, and 13 pounds in 1973. In prior years the pounds of cadmium per ton of zinc ranged between 10 and 12. In recent years, primary producers have been making more compounds at the expense of metal.

Cadmium sulfide production (including cadmium sulfoselenide and lithopone) declined 18% from that of 1975, slightly more than the rate of decline for metal production.

Cadmium oxide was produced at two of the seven primary-metal-producing plants. One plant reported secondary production, which was remelted metal or refined cadmium. Data on cadmium oxide production are not published to avoid disclosing individual company confidential data.

Table 2.— Primary cadmium producers in the United States in 1976

Company	Plant location
AMAX Zinc Co. Inc	Sauget, Ill.
ASARCO, Inc	Corpus Christi, Tex.
Do	Denver, Colo.
Bunker Hill Co	Kellogg, Idaho
National Zinc Co	Bartlesville, Okla.
New Jersey Zinc Co	Palmerton, Pa.
St. Joe Minerals Corp	Monaca, Pa.

Table 3.—Cadmium sulfide produced in the United States

(Short tons)

Year	Sulfide[1] (cadmium content)
1972	1,357
1973	1,412
1974	1,085
1975	987
1976	804

[1]Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

Actual consumption data are not gathered by the Bureau of Mines. The apparent consumption of cadmium, 5,932 tons, was 76% above that of 1975. Metal used for electroplating hardware used in transportation vehicles and stationary mechanical and electrical equipment was estimated to account for slightly less than half of the total U.S. cadmium consumption. Cadmium compounds used for red, orange, and yellow pigments and other compounds used as plastics stabilizers accounted for an additional one-third of U.S. consumption. The remainder of U.S. consumption was accounted for by cadmium metal and compounds used in alloys, nickel-cadmium batteries, and specialized electronic devices.

Table 4.—Supply and apparent consumption of cadmium

(Short tons)

	1975	1976
Stocks—beginning	1,596	2,841
Production	2,193	2,256
Imports, metal	2,618	3,411
Government sales	--	63
Total supply	[r]6,407	8,571
Exports	198	252
Stocks—end	2,841	2,387
Apparent consumption[1]	[r]3,368	5,932

[r]Revised.
[1]Total supply minus exports and yearend stocks.

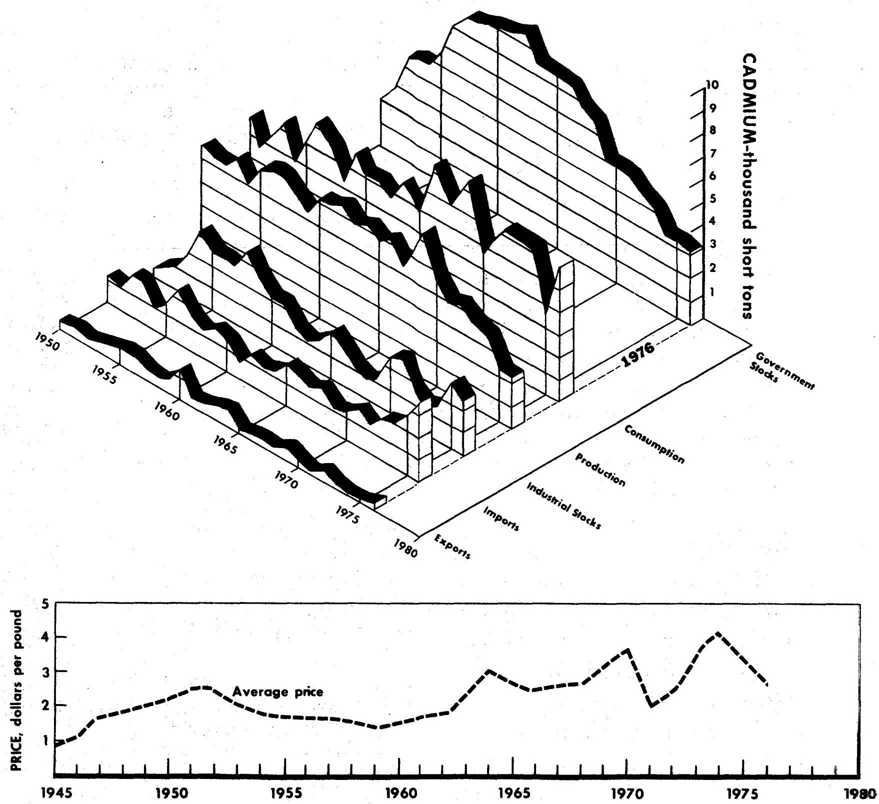

Figure 1.—Trends in production, consumption, yearend stocks, exports, imports, and average price of cadmium metal in the United States.

STOCKS

Stocks of cadmium metal held by metal producers at the end of 1976 decreased 34% to 1,369 tons. The metal stocks of compound manufacturers increased 23%, and metal stocks of distributors increased 31%.

Table 5.—Industry stocks, December 31

(Short tons)

	1975		1976	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	2,073	W	1,369	W
Compound manufacturers	133	388	163	547
Distributors	213	34	279	29
Total	2,419	422	1,811	576

W Withheld to avoid disclosing individual company confidential data; included with "Compound manufacturers."

PRICES

Producers, all beset by large inventories, began the year with cadmium priced at $2 per pound. Late in February, increased European prices put upward pressure on domestic prices. ASARCO, Inc. raised its cadmium quote to $2.50 per pound on March 8, and by March 10 all U.S. producers quoted the same price. Also on March 10 GSA raised the price for cadmium to $2.42. On April 5 ASARCO raised its price to $2.75 per pound, and National Zinc Co. and Bunker Hill Co. followed closely. By April 29, the other three producers raised their prices to the same level. Bunker Hill raised its quote to $3 per pound on August 5, and by August 31 all other U.S. producers had followed. The producer price for cadmium remained at $3 through yearend. Dealer prices were generally the same as producer prices with some discounting at the beginning and end of the year.

Table 6.—Cadmium prices, 1976

(Dollars per pound)

Date	Producer price (1- to 5-ton lots)
Jan. 1 to Mar. 8	2.00
Mar. 8 to Mar. 10	2.00–2.50
Mar. 10 to Apr. 5	2.50
Apr. 5 to Apr. 29	2.50–2.75
Apr. 29 to Aug. 13	2.75
Aug. 13 to Aug. 31	2.75–3.00
Aug. 31 to Dec. 31	3.00

FOREIGN TRADE

Exports of cadmium metal and scrap increased from 198 tons in 1975 to 252 tons in 1976. The principal recipient countries were Belgium-Luxembourg, 51%; the Netherlands, 30%; and France 13%.

Imports of cadmium metal increased 30% over those of 1975. Canada was the largest supplier of metal with 31% of the total, followed by Australia, 12%; Mexico, 12%; Yugoslavia, 9%; Belgium-Luxembourg, 8%; West Germany, 4%; France, 4%; and the Republic of Korea, 3%. The cadmium content of flue dust imported from Mexico decreased 29% from that of 1975.

Table 7.—U.S. exports of cadmium metal and cadmium in alloys, dross, flue dust, residues, and scrap

Year	Quantity (short tons)	Value (thousands)
1974	31	$238
1975	198	589
1976	252	713

Table 8.—U.S. imports for consumption[1] of cadmium metal and cadmium flue dust, by country

Country	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Cadmium metal:				
Australia[2]	398	$2,006	421	$2,003
Austria	5	35	--	--
Belgium-Luxembourg[2]	603	3,544	279	1,330
Brazil	6	22	--	--
Canada[2]	279	1,611	1,052	5,361
Congo	17	103	--	--
Finland	4	21	43	237
France	81	428	130	533
Germany, West	225	1,091	133	576
India	--	--	40	187
Italy	--	--	32	146
Korea, Republic of	55	259	110	478
Mexico	214	1,359	393	1,696
Netherlands[2]	68	304	52	220
Peru	178	843	95	419
Poland	17	89	--	--
Spain[2]	120	507	39	173

See footnotes at end of table.

Table 8.—U.S. imports for consumption[1] of cadmium metal and cadmium flue dust, by country —Continued

Country	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Cadmium metal —Continued				
U.S.S.R.[2]	--	--	193	$133
United Kingdom	55	$265	11	65
Yugoslavia	77	406	322	611
Zaire	216	1,009	66	343
Total	2,618	13,902	3,411	14,511
Flue dust (cadmium content):				
Mexico	346	1,489	246	536
Grand total	2,964	15,391	3,657	15,047

[1]General imports and imports for consumption were the same in 1975 and 1976.
[2]Includes waste and scrap (gross weight).

WORLD REVIEW

World smelter production of cadmium increased 9% over that of 1975. Japan, the U.S.S.R., the United States and West Germany were the largest cadmium producers with 17%, 16%, 10%, and 9%, respectively, of the world total. Apparent U.S. consumption was 30% of world production.

On July 12 the Cadmium Association was formed in London. The Association is operated in conjunction with the Lead and Zinc Development Association and will include cadmium producers outside the United States and Canada. The U.S. counterpart is the Cadmium Council, formed earlier in the year as part of the Zinc Institute, Inc. Both organizations will cooperate in technical publications, development work, and market surveys. The first joint meeting was scheduled to be held at the First International Cadmium Conference in San Francisco, Calif., from January 31 through February 2, 1977.

TECHNOLOGY

Cadmium in the environment and its effects on human health remained an important area of research. An isotope dilution technique was developed in Australia to establish a baseline for other measurements of the environmental levels of cadmium. Sensitivity of the technique was reported as 0.02 to 0.10 microgram per liter.[2] The effects of chronic exposure to cadmium were evaluated including those in glucose homeostasis, the glandular system, and the central nervous system.[3] Cadmium metabolism in animals was the subject of a study that concluded that muscle meat and milk of animals fed a high-cadmium diet were safe for human consumption.[4] The influence of factors such as soil pH, the presence of ammonium nitrate, and soil type on the accumulation of cadmium from superphosphate fertilizers was studied. These fertilizers contain up to 100 parts per million (ppm) cadmium, and uptake by crops has been a cause for concern.[5] The assimilation of cadmium by shellfish was the subject of two investigations. In one study, oysters exposed to seawater containing 0.005 ppm cadmium for 40 weeks were found to have accumulated up to 10.75 ppm cadmium.[6] Another study determined the accumulation of cadmium in various shellfish which were under intensive cultivation using municipal wastes as a nutrient

[2]Rosman, K., and J. R. DeLaeter. Low Level Determination of Environmental Cadmium. Nature (United Kingdom), v. 261, No. 5562, June 24, 1976, pp. 685-686.
[3]Singhâi, R. L., Z. Merali, and P. D. Hardina. Aspects of the Biochemical Toxicology of Cadmium. Fed. Proc., Federation Am. Soc. Exp. Biol., v. 35, No. 1. January 1976, pp. 75-80.
[4]Neathery, M. W., and W. J. Miller. Cadmium Toxicity and Metabolism in Animals. Feedstuffs, v. 48, No. 3, Jan. 19, 1976, pp. 30-32.
[5]Williams, C. H., and D. J. David. The Accumulation in Soil of Cadmium Residues From Phosphate Fertilizers and Their Effect on the Cadmium Content of Plants. Soil Sci., v. 121, No. 2, February 1976, pp. 86-93.
[6]Zaroogian, G. E., and S. Cheer. Accumulation of Cadmium by the American Oyster, Crassotrea Virginica. Nature (United Kingdom), v. 261, No. 5559, June 3, 1976, pp. 408-410.

Table 9.—Cadmium: World smelter production, by country[1]

(Short tons)

Country	1974	1975	1976[p]
North America:			
Canada (refined)	1,370	1,314	1,422
United States[2]	3,333	2,193	2,256
Latin America:			
Mexico	581	646	[e]660
Peru	201	176	[e]180
Europe:			
Austria	29	33	[e]35
Belgium	1,150	1,065	[e]1,290
Bulgaria[e]	220	220	250
Finland	172	239	[e]480
France	710	502	[e]600
Germany, East[e]	20	22	22
Germany, West	1,476	1,122	[e]1,590
Italy	[r]583	451	[e]770
Netherlands[e]	105	420	420
Norway	99	52	[e]55
Poland[e]	390	390	400
Romania	99	97	[e]100
Spain	196	227	[e]230
U.S.S.R.[e]	[r]2,850	[r]2,900	3,000
United Kingdom	309	289	217
Yugoslavia[e]	260	300	300
Africa:			
South-West Africa[3]	139	130	[e]130
Zaire	299	291	[e]300
Zambia	14	9	[e]10
Asia:			
China, People's Republic of[e]	120	120	120
India	65	60	[e]65
Japan	3,337	2,929	[e]3,200
Korea, North[e]	120	120	130
Oceania: Australia (refined)	[r]794	608	[e]660
Total	[r]19,041	16,925	18,892

[e]Estimate. [p]Preliminary. [r]Revised.

[1]This table gives unwrought metal production from ores, concentrates, flue dusts, and other materials of both domestic and imported origin. Sources generally do not indicate if secondary metal (recovered from scrap) is included or not; where known, this has been indicated by footnote. Data derived in part from World Metal Statistics (published by World Bureau of Metal Statistics, London) and from Metal Statistics (published by Metallgesellschaft Aktiengesellschaft, Frankfurt am Main). Cadmium is produced in ores, concentrates, and/or flue dusts in a number of other countries, but these materials are exported for treatment elsewhere to recover cadmium metal; therefore, such output is not recorded in this table to avoid double counting.

[2]Includes secondary.

[3]Output of Tsumeb Corp. for calendar years.

source.[7] Urine analyses of Australians and Western Europeans indicated a daily cadmium intake of 30 to 50 micrograms.[8] The safety of cadmium pigments was investigated. It was concluded that cadmium pigments in plastics that came in contact with food did not leach intolerable amounts of cadmium.[9]

Comparisons were made between the corrosion resistance of electroplated zinc and cadmium coatings. It was determined that cadmium had a better resistance to marine atmospheric corrosion.[10] A summary of the practical and theoretical aspects of cadmium plating was presented which discussed various alloy systems including zinc-cadmium, cadmium-gold, and cadmium-silver.[11] A tin-10% cadmium alloy solder was found to reduce embrittlement in joining gold-plated components.[12] An outline of the EPA's regulations on plating

[7]Kerfoot, W. B., and S. A. Jacobs. Cadmium Accrual in Combined Wastewater Treatment-Aquaculture System. Environmental Sci. and Technol., v. 10, No. 7, July 1976, pp. 662-667.

[8]Miller, G. J., M. J. Wylie, and D. McKeown. Cadmium Exposure and Renal Accumulation in an Australian Urban Population. Med. J. Australia, v. 1, Nos. 1-2, January 1976, pp. 20-23.

[9]Streatfield, G. R. The Safety of Cadmium Pigments. Pigment Resin Technology (United Kingdom), v. 5, No. 6, June 1976, p. 18.

[10]Mohler, J. B. Zinc Versus Cadmium Coatings. Met. Finishing, v. 74, No. 2, February 1976, p. 72.

[11]Raub, E. Theoretical and Practical Aspects of Alloy Plating. Plating Surface Finishing, v. 63, No. 3, March 1976, pp. 30-43.

[12]Duckett, R., and M. L. Ackroyd. The Influence of Solder Composition on the Embrittlement of Soft-Soldered Joints on Gold Coatings. Electroplating Met. Finishing (United Kingdom), v. 29, No. 5, May 1976, pp. 13-14, 16, 18-20.

effluents was given,[13] and methods and costs were discussed.[14] One plater reported using an evaporator to concentrate its effluents. This not only eliminated cadmium pollution but saved $9,000 worth of chemicals annually.[15]

An investigation was conducted into the mechanism by which cadmium nucleants lower the corrosion rate of lead-4% antimony alloys for batteries. Corrosion rate reductions of 50% were attained by the addition of 0.1% cadmium.[16] A photovoltaic cell using n-type cadmium sulfide or cadmium selenide cells in a sodium hydroxide electrolyte was studied. Power output of 0.14 milliwatt with an efficiency of 1% was attained.[17] A method for extracting cadmium, indium, and zinc from aqueous solutions using a phosphoric acid ester was patented.[18] Special applications of nickel-cadmium batteries were reported including a quartz wristwatch, a light aircraft powered by a bank of 120 cells, a standby lighting source, and a power supply for a deep-sea camera unit.[19]

Developments in cadmium technology are abstracted in Cadmium Abstracts, a bimonthly publication available from the Zinc Institute, Inc., 292 Madison Ave., New York, N.Y. 10017.

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[13]Lawes, B. C. The Plating Industry, EPA and 1983, Part 1. Products Finishing, v. 40, No. 8, May 1976, pp. 60-68.

[14]———. The Plating Industry, EPA and 1983, Part 2. Products Finishing, v. 40, No. 9, June 1976, pp. 64-76.

[15]Products Finishing. Loop Closed on Cadmium. V. 40, No. 6, March 1976, pp. 50-53.

[16]Abdul Azim, A. A., K. M. El-Sobki, and A. A. Khedir. The Effect of Some Alloying Elements on the Corrosion Resistance of Lead-Antimony Alloys - Part 1: Cadmium. Corrosion Sci. (United Kingdom), v. 16, No. 4, 1976, pp. 209-218.

[17]Ellis, A. B., S. W. Kaiser, and M. S. Wrighton. Visible Light to Electric Energy Conversion. Stable Cadmium Sulfide and Cadmium Sulfoselenide Photoelectrodes in Aqueous Electrolytes. J. Am. Chem. Soc., v. 68, No. 6, Mar. 17, 1976, pp. 1635-1637.

[18]Bayer AG and Duisburger Kupferhutte. Selective Extraction of Zinc, Cadmium and Indium From Aqueous Solutions. Brit. Pat. 1,428,278, Mar. 17, 1976.

[19]International Nickel Co. Inc. Nickel-Cadmium Batteries Provide Rechargeable Power for Flight-Time-Light Research. Nickel Topics, v. 29, No. 1, 1976, pp. 5-6.

Calcium and Calcium Compounds

By J. W. Pressler[1]

Calcium metal was manufactured by one company in Connecticut. Calcium chloride was produced by two companies in California and three companies in Michigan. Synthetic calcium chloride was manufactured by one company in New York and two companies in Washington.

DOMESTIC PRODUCTION

Pfizer Inc. produced calcium metal at Canaan, Conn., by the Pidgeon process, in which quicklime and aluminum powder are heated in vacuum retorts; at a temperature of 1,170° C, calcium vaporizes and is collected at one end of the retort.

National Chloride Co. of America and Leslie Salt Co. produced calcium chloride from wells in San Bernardino County, Calif. Output increased 15%. The Dow Chemical Co., Michigan Chemical Corp., and Wilkinson Chemical Corp. recovered calcium chloride from brine in Gratiot, Lapeer, Mason, and Midland Counties, Mich. Output increased 9%. Total production of natural calcium chloride was 649,000 tons, an increase of 9% compared with 1975 production.

Allied Chemical Corp. recovered synthetic calcium chloride as a byproduct of soda ash at Syracuse, N.Y.; Reichold Chemicals, Inc. recovered synthetic calcium chloride as a byproduct of pentachlorophenol manufacture at Tacoma, Wash.; and Hooker Chemicals & Plastics Corp. manufactured calcium chloride at Tacoma using limestone and hydrochloric acid. Total output of synthetic calcium chloride was 248,000 tons, an increase of 6% compared with that of 1975.

The total value of all calcium chloride sold in 1976 was an alltime record high of $47 million.

CONSUMPTION AND USES

Calcium metal was used as a reducing agent to separate metals such as columbium, tantalum, thorium, titanium, uranium, vanadium, and zirconium from their oxides; to form alloys with aluminum, lead, lithium, magnesium, and silicon; as a scavenger in the steel industry; and in the manufacture of calcium hydride. The use of calcium metal in the new maintenance-free (MF) storage battery increased rapidly in 1976, with two of the largest battery producers reporting threefold increases in the production of Pb-Ca MF batteries. General Motors Corp. was apparently committed to the use of MF batteries in 65% of its cars in 1977 and 100% by 1980.

The principal use of calcium chloride was to melt snow and ice from roads, streets, bridges, and pavements. Calcium chloride is more effective at lower temperatures than rock salt and is mainly used in the northern and eastern States. Because of its considerably higher price, it is used in conjunction with rock salt for maximum effectiveness

[1]Physical scientist, Division of Nonmetallic Minerals.

and economy. It was also used to stabilize the surface of roads and driveways for dust reduction and as a set-accelerator for concrete.

PRICES AND SPECIFICATIONS

The price of calcium metal crowns was maintained at $1.33 per pound through all of 1976; the last increase was March 21, 1975. The price of calcium-silicon alloy decreased from 57 cents per pound to 51 cents on January 21, 1976, and maintained that level throughout the remainder of the year. Published prices and specifications at yearend were as follows:

	Value per pound
Calcium metal, 1-ton lots, 50-pound full crowns, 10 by 18 inches, Ca+Mg 99.5%, Mg 0.7%	$1.33
Calcium-silicon alloy, 32% calcium, carload lots, f.o.b. shipping point	.51

Source: Metals Week. V. 48, No. 1, Jan. 3, 1976, p. 4.

Calcium metal is usually sold in the form of crowns, broken pieces, or billets, shipped in 55-gallon metal containers with a maximum of 300 pounds, and gasketed to provide an airtight condition, with argon atmosphere provided if desired. The U.S. Customs-declared value for calcium metal in 1976 ranged from $0.73 to $1.28 per pound, c.i.f. port of entry into the United States. This did not include the assessed tariff, which varied from 7.5% ad valorem for preferential status, to 25% ad valorem for statutory status.

Calcium chloride is usually sold either as solid flake or pellet averaging about 75% $CaCl_2$, or as a concentrated liquid averaging about 40% $CaCl_2$. The price of calcium chloride maintained its level throughout the year. Published prices and specifications at yearend were as follows:

	Value per ton[1]
Calcium chloride, regular grade, 77% to 80%, flake, bulk, carload, works	$55-$65
Calcium chloride, liquid, 40% to 45%, tankcar or tanktruck, works	22-24

[1]Differences between high and low price are accounted for by differences in quantity, quality, and location.

Source: Chemical Marketing Reporter. V. 211, No. 1, Jan. 3, 1977, p. 52.

As reported by producers on an f.o.b. warehouse basis, with conversions of all products to a 75% $CaCl_2$ basis, the average value in 1976 for natural calcium chloride was $50.68 per ton; the average value for synthetic calcium chloride was $57.92 per ton.

FOREIGN TRADE

Exports of calcium chloride, mainly to Canada and Mexico, were 33,533 tons valued at $2,578,000, compared with 28,400 tons valued at $2,314,000 in 1975. Exports of dicalcium phosphate were 32,302 tons valued at $6,460,000; leading destinations were Canada, Mexico, and Brazil. Exports of precipitated calcium carbonate, mainly to Canada and Mexico, totaled 3,411 tons valued at $735,000.

Total imports of calcium and calcium compounds were 208,000 tons valued at $15,120,000. Imports of calcium metal from Canada, the U.S.S.R., and France were 231 tons valued at $475,000. Imports of calcium chloride, mainly from Canada, were 16,000 tons valued at $480,000. Imports of other calcium compounds, mainly from Turkey, Canada, Norway, the United Kingdom, and France totaled 191,800 tons, valued at $14,160,000.

Imports of other calcium compounds included 63,770 tons of calcium nitrate, mainly from Norway; 37,230 tons of calcium cyanamide, mainly from Canada; 35,920 tons of chalk whiting, mainly from France, Switzerland, the United Kingdom, and Belgium; 30,250 tons of calcium borate from Turkey; 4,500 tons of calcium carbide from Canada and West Germany; 4,350 tons of precipitated calcium carbonate, mainly from Japan, France, Canada, and West Germany; 1,470 tons of calcium cyanide from Canada; 1,030 tons of calcium hypochlorite from Japan and Taiwan; and 6,580 tons of other compounds, mainly from the United Kingdom, Canada, and West Germany.

Table 1.—U.S. imports for consumption of calcium and calcium chloride, by year

Year	Calcium		Calcium chloride	
	Quantity (pounds)	Value	Quantity (short tons)	Value
1972	248,080	$181,437	6,128	$225,463
1973	110,407	77,864	7,357	317,007
1974	109,252	120,883	3,599	155,727
1975	70,128	77,684	12,021	597,758
1976	461,965	475,119	16,046	480,259

Table 2.—U.S. imports for consumption of calcium chloride in 1976, by country

Country	Quantity (short tons)	Value
Canada	15,886	$461,040
Germany, West	60	6,252
Japan	99	11,700
Sweden	(1)	331
United Kingdom	1	936
Total	16,046	480,259

[1]Less than 1/2 unit.

WORLD REVIEW

Canada.—Chromasco Corp. Ltd. produced calcium metal at its Haley smelter near Renfrew, Ontario. Canada continued to lead all other countries in the production of calcium metal, producing about 1 million pounds per year, with most of it exported to the United States and European countries. About 165 tons valued at $392,000 was exported to the United States, more than a sixfold increase compared with the 25 tons imported in 1975. Canada was the leading source of U.S. imports of calcium chloride.

France.—Planet Wattohm S.A., a subsidiary of Compagnie de Mokta, produced calcium metal by the Pidgeon process. About 1 ton valued at $8,800 was exported to the United States.

U.S.S.R.—Some calcium metal was produced in the U.S.S.R. Sixty-five tons of Soviet calcium metal valued at $74,297 was exported to the United States.

TECHNOLOGY

The market potential substantially increased for the use of calcium metal in the Pb-Ca and Pb-Ca-Sn MF storage battery. In 1976, battery manufacturers in the United States produced over 3 million units of this new permanent MF battery. Some technical difficulties such as sustained performance for deep-cycle operations remained to be solved, but these are of special application.

Calcium chloride was considered as a potential phase-change heat-storage material by microencapsulation in polyester resin, and small wall, floor, and ceiling panels were successfully tested.[2]

Rapidly increasing worldwide demand in the oil and gas industry for high-density, solids-free completion, packer, and workover fluids necessitated rapid expansion for the production of calcium bromide. Calcium bromide is a superior chemical in producing high-density drilling fluids, and would replace the traditional barite.[3]

[2]Lane, G. A., J. S. Best, E. C. Clarke, D. N. Glew, and G. C. Karris. Solar Energy Subsystems Employing Isothermal Heat Sink Materials. Dow Chemical Co., Midland, Mich., March 1976, 65 pp.

[3]Chemical Age. V. 113, No. 2984, Sept. 24, 1976, p. 2.

Carbon Black

By Herbert L. Franklin[1]

By early 1976 general economic recovery was well underway in the United States, and rubber industry leaders were looking forward to sales levels approximating those in the near-record year of 1972. This meant a good year for carbon black manufacturers since rubber manufacturers accounted for 93% of carbon black sales in 1976. Early optimism for high sales volumes was blunted, however, by the longest rubber workers' strike in history, which kept carbon black demand 7% below 1972 requirements. However, despite the 4-month strike, carbon black sales rose 7.1% above the depressed level of 1975.

Production of gas-based channel black, which has declined steadily for the past 10 years, ended in September when the only remaining channel-black plant was closed. Thermal-black production, which is also dependent on natural gas as a feedstock, reversed its declining trend as output increased almost 27% over 1975 levels.

Raw-material input patterns did not change significantly, although the share of natural gas feedstocks apparently increased slightly over that of 1975. The average unit cost of liquid hydrocarbon inputs, 25.72 cents per gallon in 1976, decreased slightly from that of 1975, but the cost for natural gas, 87.71 cents per thousand cubic feet in 1976, was up sharply.

Use of carbon black as a colorant in foodstuffs and cosmetics was banned by the Food and Drug Administration (FDA) because it was believed to contain a cancer-causing substance, but this action affected only a small portion of carbon black sales. However, a new type of plastic tire has reportedly been developed that could lead to a significant reduction in carbon black sales as a rubber-compounding agent.

Pricing problems continued to plague the industry as demand levels, suppressed by the rubber workers' strike, remained low. Price increases by yearend were considered inadequate to offset rising costs.

[1]Mineral specialist, Division of Petroleum and Natural Gas.

Table 1.—Salient statistics of carbon black produced from liquid hydrocarbons and natural gas in the United States

(Thousand pounds)

	1972	1973	1974	1975	1976
Production:					
Channel process	22,378	14,222	W	W	W
Furnace process	3,178,731	3,485,719	3,390,325	2,741,832	3,004,339
Total	3,201,109	3,499,941	W	W	W
Shipments (including losses):					
Domestic	3,148,114	3,314,646	3,147,980	2,729,772	2,911,680
Exports	r111,328	192,665	192,970	74,268	110,760
Total	r3,259,442	3,507,311	3,340,950	2,804,040	3,022,440
Producer stocks Dec. 31	r237,695	r230,325	293,903	231,695	213,594
Value:					
Production ______ thousand dollars__	$248,361	$284,153	$372,281	r$313,646	$392,601
Average per pound __________cents__	7.76	8.12	10.98	r11.44	13.07

rRevised. W Withheld to avoid disclosing individual company confidential data.

[1]Excludes channel black.

DOMESTIC PRODUCTION

Production Trends.—In 1976, carbon black production rebounded from the recessionary levels of 1975 to 3,004 million pounds plus an undisclosed amount of channel black. However, this was substantially lower than early forecasts, which predicted a return to a high level of activity similar to that achieved in 1972. General economic recovery and the resultant increase in demand for rubber products, particularly tires, would have supported early optimistic estimates. However, a 4-month strike by rubber workers suppressed rubber production and hence reduced sales of carbon black, which were about 7% below expected levels.

Production by State.—Texas and Louisiana, with the greatest concentration of carbon black production facilities and proximity to raw materials, comprised the geographic center of national production. Texas was the leading producer with 44% of national output, and Louisiana was second with 34%. The remaining U.S. production took place in Alabama, Arkansas, California, Kansas, Ohio, Oklahoma, and West Virginia.

Production by Grade and Type.—Furnace-combustion processing remained the dominant method of production with 94.9% of reported output; thermal cracking facilities accounted for the remainder. An undisclosed amount of channel black was also produced. Processing methods based on liquid hydrocarbon feedstocks accounted for 84.2% of the reported national output. Products of the liquid hydrocarbon feedstocks included General Purpose Furnace (GPF), Fast Extruding Furnace (FEF), High Abrasion Furnace (HAF), Intermediate Super Abrasion Furnace (ISAF), and Super Abrasion Furnace (SAF). Surprisingly, thermal and Semi-Reinforcing Furnace (SRF) blacks, produced from natural gas feedstocks, increased their combined share of national output from 13.3% in 1975 to 15.8% in 1976.

Number and Capacity of Plants.—Although the total number of carbon black plants in operation at yearend remained at 32 (the same as in 1975), 1 plant ceased operating and another resumed operations during the year. Furnace blacks were produced at all but one of the plants currently in operation, and thermal black was produced at three facilities. In recent years channel black producers have faced rapidly rising feedstock costs and stringent environmental pollution control requirements. The environmental problems associated with channel black production were greater than those involved with the production of fur-

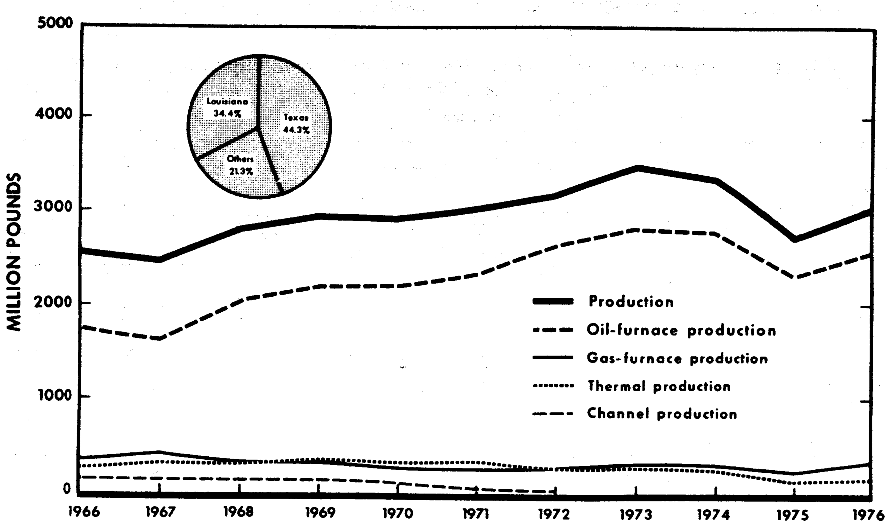

Figure 1.—U.S. production by process and geographic area.

nace blacks. By 1974, only Cities Service Co. continued producing channel black, and in September 1976 that firm closed its channel black plant at Gaines, Tex. ending channel black production in the United States. In December 1976, Continental Carbon Co. reopened its Phenix City, Ala. furnace black plant, which had been closed since late 1973. Even though industry leaders expected a steady long-term growth in demand for carbon black, aggregate daily production capacity dropped for the second straight year, and no new domestic plant developments were reported. Capacity additions to existing facilities were designed mainly to replace older inefficient equipment rather than to increase overall productive capability. The lack of development activity was attributed primarily to unsatisfactory earnings, which failed to generate the capital necessary for large-scale expansion. However, it might also be noted that only 82% of existing capacity (based on 350 days of operation) was utilized.

Materials Used and Yields.—Carbon black production consumed greater amounts of both liquid hydrocarbons and natural gas during 1976 as the industry rebounded from the low output levels of 1975. Liquid hydrocarbons continued their dominance as a feedstock with 561.3 million gallons used to produce 2,859 million pounds of carbon black, or 95.2% of total production. Yields from liquid hydrocarbons increased slightly, from 5.04 pounds per gallon in 1975 to 5.09 pounds per gallon in 1976. Because natural gas data reported encompass both fuel and feedstock use, comparisons with liquid hydrocarbons cannot be made. However, in view of the increased share of natural-gas-based blacks produced, compared with total U.S. output, it can be deduced that natural gas actually increased its significance as a raw material as well as a processing fuel. The unit cost of liquid hydrocarbons used as feedstocks decreased slightly, from 26 cents per gallon in 1975 to 25.72 cents per gallon in 1976, thus interrupting the increasing trend of the past 5 years. Natural gas costs, however, continued their steep ascent with an increase of 26.2% over 1975 costs as the average price rose to 87.71 cents per thousand cubic feet.

CONSUMPTION AND USES

Early in 1976 economic indicators pointed toward a strong recovery in demand for carbon black from the depressed levels of 1975. Greater rubber demand was predicted, primarily on the basis of an upturn in construction activity, extensive bicentennial travel and thus greater tire use, required replacement of tires on the record number of new cars sold in 1973, trends indicating increased sale of new cars, and consumer preference for large cars requiring large tires. Thus it appeared that rubber production, which has traditionally accounted for more than 90% of carbon black use, would boost carbon black sales back to the levels of 1972.

During the first 4 months, shipments exceeded 1972 levels, and early optimistic forecasts appeared valid. However, a 4-month strike by rubber workers caused shipments during May through August to plummet 28% below those of the same period in 1972. Accelerated poststrike activity by the rubber industry stimulated demand for carbon black, thus causing sales to rise 6% above 1972 levels for the final 4 months of the year. However, this final acceleration in demand was not enough to overcome the impact of the strike, and sales totals for the year ended 7% below the 1972 level.

Traditional domestic use patterns changed very little during 1976. Rubber manufacturers consumed 93% of available carbon black with 60% used for tire production and 33% for other rubber products, particularly hoses and belts for vehicles, machinery, and construction equipment. Printing inks used 2.7% of the available product, and other non-rubber industries including paint, paper, chemical, food processing, metallurgy, and plastics used the remaining 4.3%.

Carbon black use in cosmetics and food manufacture was banned by the FDA because there was no reliable test to assure that the colorant is free of a cancer-causing byproduct. The byproduct, produced during manufacture of carbon black, adheres tightly to the surface of the carbon, and extreme heat and special solvents are required for its removal.

If a new type of tire, developed by Polyair, an Austrian plastic machinery maker, can be produced economically and proves to be technically feasible, it will have a major impact on rubber manufacturers and hence on the carbon black industry. The tire is known as a liquid injection molding (LIM) tire and is made of a polyurethane plastic. It has been reported that the tire can get up to 60,000 miles of tread life, is lighter than steel-belted radials, and can run up to 50 miles at 50 miles per hour after being punctured. However, raw material costs are expected to be higher than for the conventional rubber tire. An LIM tire production plant is scheduled to begin operating in Berlin, Germany, during 1977, and a second plant, also in Germany, may startup in 1978.

STOCKS

As of December 31, 1976 producers' stocks were at their lowest level since 1969. A significant drawdown occurred during the first quarter as rubber producers accelerated production in anticipation of a strike. During the subsequent 5 months producer stocks were increased 65.9 million pounds. Immediately following the strike in September, however, heavy demand by rubber manufacturers resulted in a drawdown of 77.6 million pounds. Demand remained strong for the rest of the year, and ending stocks were 8% lower than at the close of 1975.

Drawdowns occurred in all grades of carbon black except SRF and FEF. The greatest depletion took place in thermal blacks for the second straight year, and supplies at yearend were 35.2% less than that of 1975; this drawdown occurred despite a 26.6% increase in thermal black output during the year. Substantial increases in production of SRF and FEF blacks led to increased supplies of both grades at yearend; FEF blacks increased most significantly, rising nearly 55% above the 1975 yearend level. Stocks of the most heavily used blacks, HAF and GPF, decreased 15.7% and 19.1%, respectively.

PRICES

Increasing feedstock and operating costs since early 1974 and slack demand in late 1974 and throughout 1975 created a cost-price dilemma for carbon black producers that extended into 1976.

The cost of raw materials has contributed most heavily to overall production costs because heavy aromatic residual oils, the principal carbon black feedstock, have another use as fuel. As their value in the fuel market increases, carbon black manufacturers are forced to pay high fuel-competitive prices to obtain the feedstocks.

The carbon black industry was optimistic in early 1976 that an emerging healthy demand for its products would permit significant price expansion to offset the constantly increasing production costs. However, early optimism for a return to the sales level of 1972 was blunted by the prolonged strike by rubber workers. Consequently, the average price of a pound of carbon black increased only about 17% above that of 1975 to 13.07 cents per pound.

According to Chemical Marketing Reporter, average yearend prices ranged from 10.13 cents per pound for GPF and SRF grades to 14.88 cents per pound for SAF. The average yearend price difference between bulk and bag quantities was 0.75 cent per pound.

FOREIGN TRADE

Bureau of the Census data show an increase in carbon black exports to about 110.8 million pounds during 1976, nearly 26% above the level of foreign sales during 1975. Nearly 42% of U.S. exports went to Europe, where France, West Germany, and the United Kingdom continued to be the principal recipients. However, shipments to the United Kingdom dropped markedly, while purchases by Belgium-Luxembourg and the Netherlands rebounded strongly from their depressed levels of 1975. North American customers increased their share of purchases from about 25% in 1975 to nearly 28% during 1976, primarily as a result of Mexican purchases, which nearly doubled. The volume of Asian purchases increased slightly, but Asia's share of total purchases from the United States declined from 21% in 1975 to about 17% during 1976. As in 1975 sales to African nations accounted for nearly 9% of U.S. exports, but the South American share of U.S. exports dropped from about 5% in 1975 to approximately 4% in 1976.

Imports of carbon black increased nearly 32% during 1976, totaling approximately 44.2 million pounds. Canada supplied 90% of U.S. foreign purchases, and Indonesia and West Germany were the next two largest suppliers, accounting for 5.3% and 3.2%, respectively. Nearly 45,000 pounds of bone black was also imported, coming mostly from West Germany and France. There were no imports of lamp black reported in 1976.

The average price received from foreign sales of carbon black increased from 16.3 and 17.6 cents per pound in 1974 and 1975, respectively, to 24.6 cents per pound in 1976. In the same time period, U.S. consumers of foreign-produced carbon black paid average prices of 14.6 and 13.0 cents per pound in 1974 and 1975, respectively, and 15.9 cents per pound in 1976.

WORLD REVIEW

During 1976, estimated world production increased 11% over the 1975 level and approached the record high of 1973. The most significant producing areas were North America with nearly 43% of the estimated total output, followed by Western Europe and the Far East with about 29% and 14%, respectively. North American and West European producers rebounded from the recession of 1975 with overall average increases in productivity of about 12%. Production in the Far East increased even more sharply, rising approximately 13%. Although Latin America is not yet one of the leading production areas, it had the largest growth rate during 1976 with an increase in output of nearly 14%. Production in Eastern Europe increased slightly at a rate of about 3%.

Latin America and the Far East remained most active in construction of new plant capacity and expansion of existing capacity. In Latin America a new plant at Capuava, Brazil began production in November 1976; capacity of this facility has not been disclosed. Facilities under construction in Brazil during 1976 included a 33-million-pound-per-year expansion of the Cia. Carbonos Coloidas plant at Candeias and an 11.5-million-pound-per-year addition to the Cia. Petroquimica Brasileira plant at Sao Paulo. Other construction activity in Latin America included a new 40-million-pound-per-year plant at Tampico, Mexico, for Hules Mexicanos S.A., a 7.3-million-pound-per-year expansion to the Petroleos del Peru plant at Talara, Peru, and new plants for United Carbon de Venezuela of 35 million pounds per year at Bachaquero, Venezuela, and 21 million pounds per year at Valencia, Venezuela. In the Far East, a plant of undisclosed capacity was being constructed for Union Carbon Black at Assam, India, a 28-million-pound-per-year plant was under construction for Malaysian Carbon Seniderian Berhad at Port Dickson, Seremban, Malaysia; and a 10-million-pound-per-year plant was being erected for National Refinery, Ltd., at Karachi, Pakistan. In the Near East, a 15-million-pound-per-year plant was being constructed for Petkim Petrokimya, A.S., at Yarimca, Turkey.

TECHNOLOGY

A process for chemically decomposing scrap tires by pyrolysis was being tested by The Oil Shale Corp. (TOSCO) at its test facility near Rocky Flats, Colo. It is believed that an average of nearly 6 pounds of carbon black can be recovered from each tire by the TOSCO process.

The only other significant development reported during 1976 was the introduction of a new product known as Opal Black. This product, developed by Micro Chemical Industries, Inc., is cited as a substitute for thermal black in certain rubber-compounding applications. Opal Black is a fine-particle, high-surface-area, amorphous silica with carbon dispersed within the silica matrix. It is produced by burning rice hulls under special controls and grinding the ash residue into extremely fine particles.

Table 2.—Carbon black produced from liquid hydrocarbons and natural gas in the United States, by State

(Thousand pounds)

	1972	1973	1974	1975	1976	Change from 1975 (percent)
Louisiana	1,077,977	1,207,708	1,192,795	887,719	1,032,510	+16.3
Texas	1,425,874	1,511,127	1,434,797	1,228,195	1,330,004	+8.3
Other States	697,258	781,106	762,733	625,918	641,825	+2.5
Total	3,201,109	3,499,941	3,390,325	2,741,832	3,004,339	+9.6

Table 3.—Production, shipments and stocks of carbon black in the United States in 1976, by grade

(Thousand pounds)

	SRF	GPF	FEF	HAF	SAF	ISAF	Thermal	Total[1]
Production	320,937	597,352	359,158	1,315,797	24,850	231,876	154,369	3,004,339
Shipments	318,387	604,111	349,292	1,330,723	25,999	232,349	161,579	3,022,440
Stocks at Dec. 31, 1976	24,727	28,690	27,841	79,859	6,714	32,486	13,277	213,594

[1]Excludes channel black to avoid disclosing of individual company confidential data.

Table 4.—Number and capacity of furnace black plants operated in the United States

State	County or parish	Number of plants		Total daily capacity (pounds)	
		1975	1976	1975	1976
Texas	Aransas	1	1	4,925,774	4,843,201
	Gray	1	1		
	Harris	1	1		
	Howard	2	2		
	Hutchinson	2	2		
	Montgomery	1	1		
	Moore	1	1		
	Orange	1	1		
	Terry	1	1		
	Wheeler	1	1		
Total Texas		12	12	4,925,774	4,843,201
Louisiana	Avoyelles	1	1	3,735,467	3,117,692
	Calcasieu	1	1		
	Evangeline	1	1		
	Ouachita	2	2		
	St. Mary	3	3		
	West Baton Rouge	1	1		
Total Louisiana		9	9	3,735,467	3,117,692
Alabama	Russell	--	1	2,499,143	2,512,802
Arkansas	Union	1	1		
California	Kern	3	3		
Kansas	Grant	1	1		
Ohio	Lucas	1	1		
	Washington	1	1		
Oklahoma	Kay	1	1		
West Virginia	Marshall	1	1		
	Pleasants	1	1		
Total other States		10	11	2,499,143	2,512,802
Total United States		31	32	11,160,384	10,473,695

Table 5.—Fuel and feedstocks used in carbon black production, by State

	Louisiana	Texas	Other States[1]	Total
1975				
Carbon black production:				
Total ______ thousand pounds__	887,719	1,228,195	625,918	2,741,832
Value[r] ______ thousand dollars__	$105,394	$136,146	$72,106	$313,646
Average value[r] ______ cents per pound__	11.87	11.08	11.52	11.44
Natural gas used:				
Total ______ million cubic feet__	13,984	7,669	4,593	26,246
Value ______ thousand dollars__	$9,733	$4,702	$3,803	$18,238
Average value ______ cents per thousand cubic feet__	69.60	61.31	82.79	69.49
Liquid hydrocarbons used:				
Total ______ thousand gallons__	156,326	237,887	123,185	517,398
Value ______ thousand dollars__	$42,184	$58,767	$33,577	$134,528
Average value ______ cents per gallon__	26.98	24.70	27.25	26.00
Carbon black produced ______ thousand pounds__	781,813	1,209,114	614,639	2,605,566
1976				
Carbon black production:				
Total ______ thousand pounds__	1,032,510	1,330,004	641,825	3,004,339
Value ______ thousand dollars__	$141,957	$163,839	$86,805	$392,601
Average value ______ cents per pound__	13.75	12.32	13.52	13.07
Natural gas used:				
Total ______ million cubic feet__	14,399	8,866	4,768	28,033
Value ______ thousand dollars__	$12,433	$6,529	$5,625	$24,587
Average value ______ cents per thousand cubic feet__	86.34	73.64	117.97	87.71
Liquid hydrocarbons used:				
Total ______ thousand gallons__	182,871	254,201	124,248	561,320
Value ______ thousand dollars__	$47,063	$63,652	$33,681	$144,396
Average value ______ cents per gallon__	25.74	25.04	27.11	25.72
Carbon black produced ______ thousand pounds__	936,293	1,293,121	629,381	2,858,795

[r]Revised
[1]Alabama, Arkansas, California, Kansas, Ohio, Oklahoma, and West Virginia.

Table 6.—Liquid hydrocarbons and natural gas used in manufacturing carbon black in the United States and average yield

	1972	1973	1974	1975	1976
Natural gas used ______ million cubic feet__	53,939	49,682	40,130	26,246	28,033
Average value of natural gas used per thousand cubic feet ______ cents__	19.54	24.19	40.87	69.49	87.71
Liquid hydrocarbons used ______ thousand gallons__	590,753	623,236	578,811	517,398	561,320
Average yield of carbon black per gallon ______ pounds__	4.96	5.22	5.54	5.04	5.09
Average value of liquid hydrocarbons used per gallon ______ cents__	8.13	9.03	23.87	26.00	25.72
Number of producers reporting ______	8	8	8	8	8
Number of plants ______	34	34	34	32	32

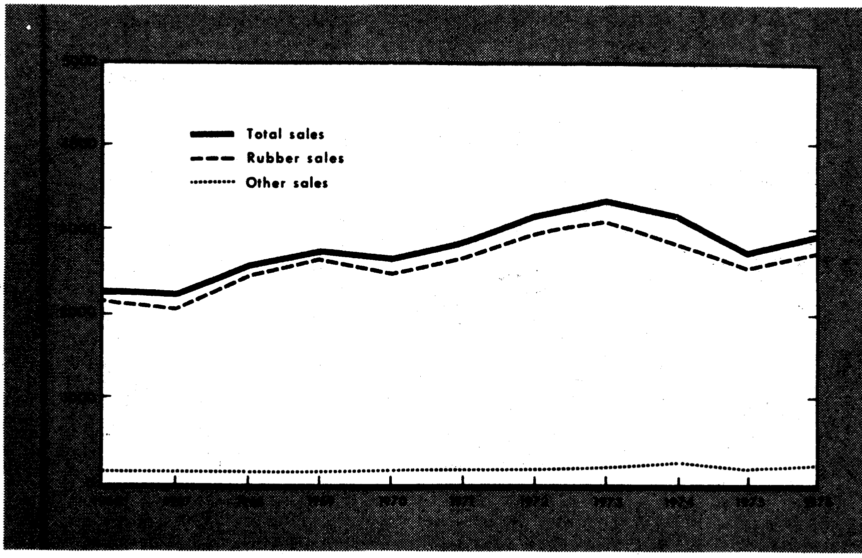

Figure 2.—Sales for domestic consumption.

Table 7.—Sales of carbon black for domestic consumption in the United States, by use

(Thousand pounds)

Use	1972	1973	1974	1975	1976	Change from 1975 (percent)
Ink	82,532	84,364	83,009	72,326	79,758	+10.3
Paint	21,408	21,667	18,936	18,437	19,310	+4.7
Paper	4,225	4,212	3,604	4,241	3,321	-21.7
Rubber	2,953,779	3,114,565	2,925,032	2,553,778	2,719,968	+6.5
Miscellaneous[1]	84,764	88,786	115,939	80,675	102,235	+26.7
Total	3,146,708	3,313,594	3,146,520	2,729,457	2,924,592	+7.1

[1]Includes chemical, food, metallurgical, and plastics

Table 8.—Carbon black average domestic yearend prices, by grade

(Cents per pound)

	1975	1976
Channel	12.50	12.50
Fast Extruding Furnace (FEF)	11.00	10.88
General Purpose Furnace (GPF)	10.25	10.13
High Abrasion Furnace (HAF)	12.00	12.00
Intermediate Super Abrasion Furnace (ISAF)	13.25	13.13
Super Abrasion Furnace (SAF)	15.00	14.88
Semi-Reinforcing Furnace (SRF)	10.25	10.13
Thermal	12.00	12.00

Table 9.—U.S. exports of carbon black, by country

(Thousand pounds and thousand dollars)

Country	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
North America:						
Canada	15,170	2,259	13,956	1,878	16,458	2,878
Costa Rica	4	8	337	62	353	70
Dominican Republic	--	--	46	3	54	4
El Salvador	47	6	471	10	165	31
Guatemala	1,333	159	8	5	306	67
Honduras	100	20	--	--	26	5
Jamaica	1,170	141	9	8	13	3
Mexico	6,507	446	6,718	977	13,175	1,789
Other	72	13	r19	r12	7	5
Total	24,403	3,052	21,564	2,955	30,557	4,852
South America:						
Argentina	1,077	198	379	125	294	133
Brazil	17,417	2,182	2,028	413	2,715	723
Chile	340	81	594	100	140	28
Colombia	959	119	188	60	271	77
Ecuador	24	4	61	22	30	11
Peru	263	61	260	55	316	75
Uruguay	66	8	40	13	64	13
Venezuela	651	101	884	187	671	176
Other	33	5	20	6	17	5
Total	20,830	2,759	4,454	981	4,518	1,241
Europe:						
Austria	92	24	--	--	562	132
Belgium-Luxembourg	5,014	724	735	155	3,603	961
Denmark	772	253	56	33	563	184
Finland	117	32	66	20	27	12
France	23,255	3,733	9,122	1,427	14,427	3,362
Germany, West	15,444	2,246	5,562	923	8,778	2,224
Hungary	81	30	22	8	48	18
Italy	5,892	1,503	2,234	530	3,302	1,266
Netherlands	10,174	2,459	873	249	2,948	879
Norway	265	37	113	16	180	68
Poland	47	7	28	14	81	52
Portugal	172	33	272	45	183	126
Romania	410	168	44	117	41	106
Spain	5,188	1,029	2,081	357	2,849	900
Sweden	480	99	1,046	207	1,028	257
Switzerland	1,397	198	201	53	132	27
United Kingdom	10,746	2,239	12,696	1,356	7,415	2,467
Yugoslavia	418	31	11	3	39	14
Other	47	73	30	44	180	112
Total	80,011	14,918	35,192	5,557	46,386	13,167
Africa:						
Algeria	33	10	16	7	3	5
Angola	329	44	4	1	90	29
Egypt	--	--	23	13	11	3
Ethiopia	--	--	108	21	--	--
Ghana	2,337	349	2,750	472	2,688	598
Kenya	1,524	236	1,071	221	1,824	246
Morocco	42	8	32	6	--	--
Nigeria	--	--	13	5	256	38
South Africa, Republic of	8,945	1,049	2,796	456	3,110	594
Tanzania	1,332	246	905	166	1,689	249
Zambia	551	84	--	--	--	--
Other	35	5	r14	r4	31	5
Total	15,128	2,031	7,732	1,372	9,702	1,767

See footnote at end of table.

Table 9.—U.S. exports of carbon black, by country—Continued

(Thousand pounds and thousand dollars)

Country	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
Asia:						
Cambodia	109	19	--	--	--	--
Hong Kong	253	60	252	50	340	85
India	572	135	272	74	325	114
Indonesia	1,242	176	170	33	166	42
Iran	73	16	25	7	25	9
Israel	477	61	375	67	276	83
Japan	23,452	4,577	4,727	1,962	7,085	3,526
Korea, Republic of	2,117	256	403	180	465	197
Lebanon	152	21	--	--	1	1
Malaysia	4,872	720	2,920	503	2,456	344
Pakistan	2,365	344	2,234	346	1,307	244
Philippines	1,206	124	144	26	174	45
Singapore	5,188	934	226	38	380	166
Sri Lanka	224	36	304	57	--	--
Taiwan	6,699	851	5,165	915	5,310	979
Thailand	3,713	473	658	112	384	66
Turkey	186	40	--	--	--	--
Vietnam	3,809	517	451	64	--	--
Other	18	4	8	5	--	--
Total	56,727	9,364	18,334	4,439	18,694	5,901
Oceania:						
Australia	3,483	672	352	107	751	232
New Zealand	1,155	151	319	63	152	71
Total	4,638	823	671	170	903	303
Grand total	201,737	32,947	87,947	15,474	110,760	27,231

[r]Revised.

Table 10.—U.S. exports of carbon black in 1976, by month

(Thousand pounds and thousand dollars)

Month	Channel		Furnace		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
January	439	242	7,941	1,511	8,380	1,753
February	297	261	10,869	2,167	11,166	2,428
March	628	505	9,393	1,888	10,021	2,393
April	301	222	6,789	1,560	7,090	1,782
May	508	513	7,757	1,711	8,265	2,224
June	375	308	9,445	1,977	9,820	2,285
July	292	278	9,357	2,038	9,649	2,316
August	406	292	9,789	2,125	10,195	2,417
September	139	188	9,031	2,062	9,170	2,250
October	385	349	9,612	2,246	9,997	2,595
November	706	766	6,793	1,750	7,499	2,516
December	223	144	9,285	2,128	9,508	2,272
Total	4,699	4,068	106,061	23,163	110,760	27,231

Table 11.—Carbon black: World production, by country

(Million pounds)

Country[1]	1974	1975	1976[p]
Argentina[e]	66	66	66
Australia[e]	156	140	170
Belgium[e]	4	4	4
Brazil[e]	193	200	226
Canada[e]	249	230	295
Colombia[e]	55	48	58
Czechoslovakia[e]	66	66	66
France[e]	346	325	375
Germany, West	661	575	644
Hungary[e]	10	10	10
India	143	115	130
Indonesia	6	6	[e]7
Iran[e]	4	15	30
Italy	334	301	342
Japan	830	815	901
Korea, Republic of	[r]36	53	71
Mexico[e]	75	80	90
Netherlands	[r]222	175	198
Peru	--	[e]10	[e]20
Romania	173	191	[e]200
South Africa, Republic of[e]	83	89	95
Spain	115	90	111
Sweden[e]	62	52	66
Taiwan	([2])	([2])	([2])
United Kingdom[3]	443	460	[e]463
United States	3,390	2,742	3,004
Venezuela[e]	40	37	42
Yugoslavia	41	42	[e]42
Total	[r]7,803	6,937	7,726

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, the People's Republic of China, Norway, Poland, Turkey, and the U.S.S.R. produce carbon black, but production statistics are not reported and available information is inadequate for the formulation of reliable estimates of output levels.

[2]Less than 1/2 unit.

[3]Includes vegetable black, but excludes acetylene and bone black.

Cement

By Norman E. Wingard[1]

Portland cement shipments from plants in the United States and Puerto Rico, including cement imported and distributed by domestic producers, totaled 71,922,000 tons in 1976. This amount was 6.1% higher than was shipped in 1975 but was 9.5% less than in 1974. In 1973, record high cement shipments of 86.6 million tons were recorded, 17% higher than in 1976. The 1976 figure represents a reversal in the 2-year downturn experienced during 1974-75.

Mill value for portland cement increased to $2.4 billion, 16% higher than that of 1975. This reflects an increase in the unit value of $2.77 per ton, or 9%.

The demand for cement during the year increased as the construction industry gained momentum after the recession, particularly in the first half of the year. During the first 6 months of 1976, construction was ahead of 1975. This was followed by 4 months of level activity, and the year ended with more gains in the final 2 months. Residential construction was almost solely responsible for the improvement. The number of housing starts increased from 1.15 million in 1975 to 1.55 million in 1976. In all, the construction industry developed about 75% of the volume reached in the early 1970's, representing a growth of about 8% compared with 1975 levels. The recovery of the construction industry, in fact, proceeded at a slower pace than had been expected, with the typically largest uses of cement, such as highway and industrial building, down from 1975.

Maintenance, repair, fuel, and operating costs were up significantly, especially at older plants. Higher prices, however, generally allowed companies to experience better mill-net profits despite increased production costs.

Little new capacity came onstream in 1976 or was scheduled in the near future; as a result, supply-demand approached a close balance in many market areas. With stable capacity, more plants were producing at near-capacity limits in 1976. Undercapacity within the next few years is a possibility.

Although little new capacity was developed during the year, a number of plant modernization and renovation projects were underway. Primarily aimed at increasing energy efficiency, virtually all major projects involved conversion to dry process with preheaters and the ability to use coal as a principal fuel.

Citadel Cement Corp. received an award from the city of Birmingham, Ala., for environmental improvements as a result of the installation of electrostatic precipitators in 1976. Southwestern Portland Cement Co. of Amarillo, Tex., received the 1976 Citation to Industry award from the Texas Panhandle Audubon Society for its effective reclamation of strip-mined lands. More than 70 acres of land was restored to productive grassland.

The Portland Cement Association (PCA) presented safety trophy awards to 34 plants that had injury-free operations in 1976. Medusa Cement Co. of Manitowoc, Wis., received its 29th reaward for 30 years without a disabling injury. Martin Marietta Corp.'s plants in Atlanta, Ga., and Lyons, Colo., received new trophy awards for an accident-free year. Thousand-day achievement awards were presented to three companies by the PCA: Louisville Cement Co. at Logansport, Ind., received its award for 4,000 consecutive accident-free days; and

[1]Physical scientist, Division of Nonmetallic Minerals.

Ideal Basic Industries, Inc.'s plants at Fort Collins, Colo., and Trident, Mont., each received a 1,000-day citation.

The Atlantic Cement Co., a subsidiary of Newmont Mining Corp., was awarded the Environmental Protection Agency's "Flag of Achievement" for meeting all pollution control regulations.[2] Atlantic was the first portland cement company to receive this award, and represented the only industry selected in 1976.

Again in 1976, energy continued to be a major concern in the cement industry. Major items of planned or actual capital expenditure were the conversion to coal as a primary or backup fuel in plant operations, and conversion from wet- to dry-process operation with the addition of preheaters. Several companies were involved in the development of their own coal reserves and mining facilities.

Some of the tables show statistical data arranged by State or by groups of States which form cement districts. A cement district may represent a group of States, a portion of a State, or in some cases, will correspond to a State. The States of California, New York, and Pennsylvania have been divided to provide additional marketing information. Divisions for these States are as follows:

California, Northern.—Points north and west of the northern borders of San Luis Obispo and Kern Counties and the western borders of Inyo and Mono Counties.

California, Southern.—All other counties in California.

New York, Western.—All counties west of a dividing line following the eastern boundaries of St. Lawrence, Lewis, Oneida, Madison, Chenango, and Broome Counties.

New York, Eastern.—All counties east of the above dividing line.

New York, Metropolitan.—The five counties of New York City (Bronx, Kings, New York, Queens, and Richmond) plus Westchester, Rockland, Suffolk, and Nassau Counties.

Pennsylvania, Eastern.—All counties east of the eastern boundaries of Potter, Clinton, Centre, Huntingdon, and Franklin Counties.

Pennsylvania, Western.—All other counties in Pennsylvania.

Legislation and Government Programs.—The Housing Authorization Act of 1976 allocated $675 million per year for subsidized housing. Of this amount, $85 million was for new construction or substantial rehabilitation of existing housing.

The President signed a 2-year extension of the Federal highway program for $17.6 billion. Most of this was not expected to be spent in the 2 years, because the funds were tied to State and local matching fund requirements. It was, however, the largest 2-year highway program ever enacted and would allow expenditures on interstate, primary, secondary, and urban roads.

A total of 6,775 Federally aided contracts for highway and bridge construction were awarded by State highway departments during 1976 at a cost of $5.2 billion.

The PCA and a number of cement producers were named in several civil antitrust suits filed by the Attorneys General of California, Arizona, and Colorado. The suits, on behalf of buyers and users of cement and readi-mix concrete, alleged various violations of the Sherman Anti-Trust Act and were seeking treble damages in unspecified amounts. Violations charged include price fixing and conspiracy to eliminate competition in the cement industry. Defendants, in addition to the PCA, included virtually every cement manufacturer that marketed in the States.

The Federal Trade Commission issued an order barring the Martin Marietta Corp., Ideal Basic Industries, Inc., and the OKC Corp. from exchanging price information and from controlling "the place of use" of portland cement. The order also required that the companies offer customers the option of arranging their own transportation for shipments and that they provide mill-price quotations.

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[2]Portland Cement Association. Environmental Notes. No. 2, May 1977.

Table 1.—Salient cement statistics

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
United States:[1]					
Production[2]	82,597	85,513	80,917	68,139	72,950
Shipments from mills[2 3]	83,336	88,665	81,033	69,102	73,668
Value[2 3 4]	$1,724,140	$1,975,409	$2,150,659	$2,159,160	$2,510,100
Average value per ton[2 3 4]	$20.69	$22.28	$26.54	$31.25	$34.07
Stocks Dec. 31 at mills[2]	7,036	5,512	7,467	6,930	7,154
Exports	83	268	199	417	343
Imports for consumption	4,851	6,647	5,702	3,637	3,074
Consumption, apparent[5 6]	84,952	90,679	82,862	70,062	74,136
World: Production	723,796	773,769	[r]775,183	[r]774,277	811,502

[r]Revised.
[1]Excludes Puerto Rico.
[2]Portland and masonry cement only.
[3]Includes imported cement shipped by domestic producers.
[4]Value received, f.o.b. mill, excluding cost of containers.
[5]Quantity shipped plus imports minus exports.
[6]Adjusted to eliminate duplication of imported clinker and cement shipped by domestic cement manufacturers.

DOMESTIC PRODUCTION

During 1976, 1 State agency and 57 companies operated 167 plants in 40 States. An additional two companies operated two plants in Puerto Rico, manufacturing one or more kinds of hydraulic cement.

PORTLAND CEMENT

Manufacturers in the United States and Puerto Rico produced 68,579,000 tons of clinker, and imported 962,000 tons of foreign clinker to grind 71,227,000 tons of portland cement. Domestic producers shipped 71,922,000 tons of portland cement, which included 1,201,000 tons of imported cement. Stocks at mills increased by 215,000 tons. An additional 911,000 tons of portland cement was imported and shipped or used by others not producing cement in the United States or Puerto Rico.

Production Capacity.—Multiplant operations were run by 30 companies. No single company, however, provided more than 6.3% of the Nation's total clinker production capacity. The five largest producers provided 25.5% of the total clinker production capacity; the 10 largest provided for a combined 45.3%. The 10 largest companies, in terms of clinker production capacity, were Ideal Basic Industries, Inc.; General Portland, Inc.; Amcord, Inc.; Martin Marietta Cement Corp.; Marquette Cement Manufacturing Co.; Medusa Cement Co.; Lone Star Industries, Inc.; Kaiser Cement & Gypsum Corp.; Huron Cement Div. of National Gypsum Co.; and Universal Atlas Cement Div. of United States Steel Corp.

At yearend, 405 kilns located at 157 plants were being operated by 54 companies and 1 State agency in the United States and Puerto Rico. The estimated 24-hour daily clinker production capacity was 281,000 tons. An average of 61 days downtime was reported for kiln maintenance and replacing refractory brick. Based on 304 days of operation, the annual clinker production capacity of the industry was 85.4 million tons. The industry operated at 80.2% of its apparent capacity, compared to 70% in 1975. Average annual clinker capacity of each kiln in the United States was 211,000 tons, that of each plant was 544,000 tons, and that of each producing company, 1,569,000 tons. There were 163 clinker-producing plants, 7 of which produced white cement. In addition, eight plants operated grinding mills using only imported or purchased clinker, or interplant transfers of clinker. Of these eight, six have for some years operated in this manner, one was a closed clinker-producing plant that ground clinker early in the year to dispose of stocks on hand, and one was a clinker-producing plant whose kilns remained shut down for the year. Of the grinding plants, six produced portland cement only and two ground clinker for both masonry and portland cement. Based on the fineness necessary to grind Types I and II cements and making allowance for downtime required for maintenance, the cement industry in the United States and Puerto Rico had an estimated grinding capacity of 104 million tons of cement annually.

In 1976, clinker was produced by wet-process kilns at 91 plants and by dry-process kilns at 59 plants; 7 additional plants operated both wet and dry kilns. Dry-process kilns with preheaters were replacing many older wet-process facilities and were also being extensively used in plans for new plant construction because of their higher operating efficiency and lower fuel consumption. Flash calciners were being considered for use in conjunction with these systems to further reduce fuel consumption per ton of cement produced. By yearend, 34 suspension and 16 grate preheaters were in operation in 29 plants. During the year, four new suspension preheaters were put into operation, increasing capacity more than 1 million tons per year.

Capacity Changes—New Plant Installations.—No entirely new plants were built in 1976. The latest plant to be completed was Florida Mining & Materials Corp.'s new 564,000-ton-capacity plant, which began production on December 31, 1975, and was the only new plant to be built that year. Kaiser Cement & Gypsum Corp. completed the first full year of operation of its new dry-process kiln at San Antonio, Tex.

Citadel Cement Corp., a subsidiary of Lone Star Industries, Inc., installed a new preheater kiln, two new raw mills, and converted the old raw mills to finish mills at its Roanoke, Va., plant. Capacity was to be increased from 750,000 to 1.2 million tons per year by 1977. The new preheater kiln is an Allis-Chalmers ACL system, similar to the German LEPOL design. It is a traveling-grate preheater with precalcination.

A new dry-process kiln was installed by Northwestern States Portland Cement Co. at its Mason City, Iowa, plant. The new kiln, rated at 1,060 tons per day, should provide an increase in plant capacity of 25%. In addition to the kiln, a new raw mill and finish-grinding mill, each with an output of 100 tons per hour, were added.

National Cement Co., Inc., a subsidiary of Société des Ciments-Vicat of Grenoble, France, completed a $10 million expansion project that included installation of a six-stage suspension preheater with flash calciner. An existing kiln was shortened by 150 feet, to 390 feet. Capacity was increased from 1,200 tons per day from the old kiln to 2,200 tons with the new system. Continuing into 1977, plant expansion was to include a new Loesche roller mill, a vertical-spray chamber to condition bypass gases, and storage and related materials-handling facilities. In 1978, conversion to coal as the primary fuel is planned.

A single-stage, twin-cyclone preheater kiln was installed by Lehigh Portland Cement Co. at Mitchell, Ind. Rated at 250,000 tons per year, this kiln will increase plant output capacity to 750,000 tons per year.

At the Stockertown, Pa., plant of the Hercules Cement Co. of Amcord, Inc., a three-stage suspension preheater was installed, and the existing kiln was shortened. Capacity was increased 15% to 700,000 tons per year.

At Hagerstown, Md., Marquette Cement Manufacturing Co. completed the installation of a new finish-grinding department for masonry cement. The new mill provides grinding capability to use clinker directly in the manufacture of masonry cement, rather than by blending plasticizers into portland cement as done previously. At its Superior, Ohio, plant, Marquette installed a new glass baghouse dust collector for air pollution control.

Planned Expansions and New Plants.—Marquette announced plans to build a 1-million-ton-per-year plant at Cape Girardeau, Mo. The new facility is to replace an existing wet-process plant that the company acquired in 1923. Cost of the new plant is expected to be $70 million to $80 million. Completion was expected to be in 1980. Clinker production capacity will be 950,000 tons per year, with finished cement production totaling 1,090,000 tons.

Centex Corp. announced plans to construct a new single dry-process kiln with suspension preheater near Austin, Tex. Capacity of the facility is to be 470,000 tons per year, replacing the 282,000-ton-per-year Corpus Christi plant. The $32 million plant was scheduled for completion in 1978.

Lehigh Portland Cement Co. announced that it would be increasing the capacity at its Mason City, Iowa, plant 20%, to 750,000 tons per year. Two-thirds of the output would be from new facilities, and one-third, from a kiln in operation since 1958. Six small, 65-year-old kilns capable of producing 365,000 tons of clinker per year would be scrapped. A new single 500,000-ton dry-process kiln, with four-stage preheater and flash calciner, and a new raw-grinding mill would be added by 1978, at an estimated cost of $25 million. Cost savings from the renovation was expected to be $3 million per year.[3]

Lone Star Lafarge Co., a joint venture of Lone Star Industries, Inc., and Lafarge Fondu International, announced plans for a new plant in Chesapeake, Va., to produce

[3]Lehigh Portland Cement Co. 1976 Annual Report. P. 8.

high-purity calcium aluminate cement. Lafarge, the original producer of calcium aluminate cement, has been producing the product for more than 50 years. The intended completion date was late 1977. The former grinding facility at this site was shut down.

Citadel Cement Corp. was working on a $110 million expansion to double capacity to 2.2 million tons per year by mid-1977. This capacity would place Citadel among the 10 largest cement companies in the United States. Citadel was formed in 1974 as a 50-50 joint venture between Lone Star Industries, Inc. and Canada Cement Lafarge Ltd. Two plants, at Demopolis, Ala., and Roanoke Va., and other assets were contributed by Lone Star, while expansion capital was supplied by Lafarge. Plans were developed to increase the capacity of the new Demopolis plant from 280,000 to 750,000 tons per year. A new semiportable crusher and conveying system will supply the plant with raw materials from the massive Selma Chalk. The chalk will be taken to a preblender-stacker-reclaimer at a rate of 1,000 tons per hour. A vertical roller mill will grind and dry preblended material at 176 tons per hour. Homogenized material will then feed into a four-stage preheater kiln, rated at 2,350 tons per day. Two 3,700-horsepower cement mills will grind the clinker. The Roanoke plant underwent extensive expansion.

Lone Star was progressing with the installation of high-ratio dust collectors for two clinker coolers and an 11- by 29-foot, 1,750-horsepower cement grinding mill at its Bonner Springs, Kans., plant. Plans to upgrade and expand the Santa Cruz, Calif., plant would result in replacing the older production units with a single, new 300,000-ton-per-year capacity preheater kiln, a new cooler, and a self-contained roller mill. Two new electrostatic precipitators will be added for environmental control. In addition to use in the preheater, exhaust kiln heat will also be used by the roller mill to dry the raw materials before they enter the preheater. This will eliminate the old raw material driers. The new mill is expected to require little more than half the energy formerly consumed for raw materials preparation. The new plant is intended to produce low-alkali cement for use in the San Francisco Bay area. Completion of the project was scheduled for 1979 at an estimated cost of $38 million.

Bessemer Cement Co., a subsidiary of Louisville Cement Co., announced plans to install a new 10-module Rexnord gravel bed filter system at its Bessemer, Pa., plant. A $25 million program to modernize the Speed, Ind., plant, including installation of a new 670,000-ton-per-year suspension preheater and kiln, was well underway. Production should be increased 16% to 18%, with 20% to 35% greater energy efficiency.

Installation of the largest preheater kiln in the United States was being planned by the oldest cement manufacturer in the country. Coplay Cement Manufacturing Co. designated Kaiser Engineers of Pennsylvania, Inc., to make arrangements for a $50 million modernization program. Included is a 1-million-ton-per-year preheater kiln with planetary cooler, to be supplied by Polysius, A.G., of West Germany. Additional improvements include a Pfeifer/Allis-Chalmers roller mill for raw feed, and a 6,350-horsepower F. L. Smidth & Co. finish mill. The new facilities will replace existing equipment at both the Nazareth and Coplay plants. Controlling interest in Coplay was purchased by Société des Ciments Français, which provided the capital needed to carry out the modernization. Completion was scheduled for 1978.

Ideal Basic Industries, Inc., announced plans to install a grate preheater kiln at its Boettcher, Colo., plant. The company plans to use kerogen-bearing raw materials to reduce energy costs, and increase cement production 135,000 tons per year. Kerogen, present in the limestone to be used, will supply 25% of the energy needed for burning the clinker.

Phase 3 of a 5-year, $49 million modernization by Ideal was underway at Knoxville, Tenn. Four wet units were being replaced by a dry-process kiln and preheater. Capacity will be 583,000 tons per year by early 1979, an increase of 113,000 tons per year.

At its Tijeras, New Mex. plant, Ideal was to bring a new dry-process preheater kiln on stream in 1977. This would increase the plant's capacity by 80,000 tons per year, to 500,000 tons.[4]

Oregon Portland Cement Co. planned to construct a new plant near Durkee, in eastern Oregon. The plant would have a 500,000-ton-per-year capacity, and would replace a 200,000-ton-per-year plant at Lime, Oreg., which is 12 miles from the proposed

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[4]Portland Cement Association, private communication.

plant site. Completion was projected for early 1979 at a cost of approximately $37 million. A coal-fired, dry-process, four-stage cyclone preheater kiln will be used.

The South Dakota Cement Commission was to have a new preheater kiln operational in 1977, which would increase production capacity 570,000 tons per year.[5]

Plant Closings.—During the year, seven clinker-producing plants and one grinding plant were closed down and several more were partially shut down or scheduled to close. Reasons given as the cause of these closings varied, and included the following: Inefficient old plants were unable to compete with newer, more efficient operations; the cost of obtaining raw materials was too high; many of the plants could not meet environmental emission standards; and the cost of retrofitting older facilities could not be economically justified.

On February 12, 1976, Puerto Rican Cement Co., Inc., announced the closing of its Cataño plant, while continuing to operate its main plant in Ponce. The shutdown was completed in July. The plant, which had been purchased from the Puerto Rican Government in 1950, was built in 1938, and had a capacity of 40,000 bags per day. Prior to closing, it had been operating at only about 50% capacity. Closure was brought on by higher costs, particularly for pollution control, a depressed local housing market, and an increase in production facilities in former export markets.

The directors of Valley Cement Industries, Inc., on July 19, 1976, voted to permanently discontinue cement manufacture at its Redwood, Miss., plant and to dispose of the equipment and property. The kiln was shut down on July 31.

United States Steel Corp. closed its Universal Atlas Cement Div. plant at Duluth, Minn., in January 1976, and announced plans for a possible sale to Intermix Corp. of White Pine, Mich. On September 7, 1976, United States Steel announced the pending shutdown of its Hudson cement plant on the Hudson River at Greenport, N. Y. The property, which included two dry-process kilns, rail transportation connections, and river docking and storage facilities was sold to St. Lawrence Cement Co. of Montreal, Canada.

A slowdown in building construction was cited as the major reason for the Penn-Dixie Industries, Inc., shutdown of its Howes Cave., N. Y., plant. Howes Cave was among Penn-Dixie's oldest and smallest plants, with a rated capacity of 324,000 tons per year. It had operated at less than 50% capacity for 2 years prior to shutting down.

PPG Industries, Inc., closed its underground limestone mine and cement plant near Barberton, Ohio. The operation had become uneconomical because of the high costs of underground mining of the limestone. PPG's other cement operations were sold to Filtrol Corp. in 1973.

The Flintkote Co.'s Diamond-Kosmos Cement Div. phased out the entire Middle Branch, Ohio, operation during the year. As with many other older plants, the capital investment necessary to bring the plant into compliance with air quality standards was not justified by expected returns.

General Portland Inc. permanently shut down one of the kilns at its Trinity Div. plant in Houston, Tex. Under company reorganization, the Houston plant continued limited operations through 1976 under the new Trinity South Div.

Lone Star-Citadel shut down its Norfolk plant at Chesapeake, Va., at yearend. It had previously operated as a grinding plant on imported clinker, but was no longer needed with the expansion of the Roanoke plant.

Corporate Changes.—Marquette Cement Manufacturing Co. became a wholly owned subsidiary of Gulf & Western Industries, Inc., in 1976.

Kaiser Cement & Gypsum Corp. sold its 46% equity interest in Ryukyu Cement Co., Ltd. of Japan to Ube Industries Ltd. of Japan for $6,965,000.

National Gypsum Co. combined its Huron and Allentown Cement Divisions; the respective trade names, however, were retained. The company made plans to move the corporate headquarters to Dallas, Tex., in 1977.

Société des Ciments Français purchased controlling interest in Coplay Cement Manufacturing Co. The merger provided Coplay with funds necessary to carry out plant modernization. Coplay was the first cement manufacturing firm in the United States. It was founded in 1866 by David O. Saylor, who developed and patented the first portland cement in the United States.

Missouri Portland Cement Co. became a wholly owned subsidiary of H. K. Porter Co., Inc.

Universal Atlas Cement Div. of United States Steel Corp. sold its Hudson plant in Greenport, N. Y., to the St. Lawrence Ce-

[5]Work cited in footnote 4.

ment Co. of Montreal, Canada.

Lehigh Portland Cement Co. sold its Miami, Fla., production facilities for $12 million to the Rinker Group of West Palm Beach, Fla., to form the Rinker Portland Cement Corp.

Intermix Corp. was negotiating the purchase of United States Steel's Universal Atlas Cement Div. plant at Duluth, Minn. The plant had been closed since the first of the year, owing to lack of raw materials. Intermix intended to use tailings from the White Pine Copper Co., to be shipped in by rail, and limestone from Michigan's lower peninsula, which would be shipped in by lake vessels.

Table 2.—Portland cement shipped by producers in the United States, by district[1] [2]

(Thousand short tons and thousand dollars)

District	1975			1976		
	Quantity	Value	Average per ton	Quantity	Value	Average per ton
New York and Maine	3,697	97,102	$26.27	3,723	102,686	$27.58
Eastern Pennsylvania	4,076	118,453	29.06	4,045	125,671	31.07
Western Pennsylvania	1,738	49,766	28.63	1,945	59,498	30.59
Maryland and West Virginia	1,817	53,866	29.65	1,818	54,642	30.06
Ohio	2,364	70,268	29.72	2,130	65,656	30.82
Michigan	4,573	131,324	28.72	4,931	145,381	29.48
Indiana, Kentucky, Wisconsin	3,039	88,537	29.13	3,328	98,773	29.68
Illinois	1,374	42,756	31.12	1,632	53,524	32.80
Tennessee	1,136	37,866	33.33	1,256	43,495	34.63
Virginia, North Carolina, South Carolina	2,382	76,789	32.24	2,546	83,381	32.75
Georgia	828	25,822	31.19	930	30,085	32.35
Florida	1,721	62,525	36.33	1,949	67,832	34.80
Alabama	1,968	62,599	31.81	2,134	70,365	32.97
Louisiana and Mississippi	1,388	44,723	32.22	1,508	52,388	34.74
Minnesota, South Dakota, Nebraska	1,527	49,235	32.24	1,473	52,506	35.65
Iowa	2,258	73,786	32.68	2,438	86,107	35.32
Missouri	3,962	116,260	29.34	4,353	142,976	32.85
Kansas	1,832	55,033	30.04	2,005	66,478	33.16
Oklahoma and Arkansas	2,240	67,517	30.14	2,551	86,695	33.98
Texas	7,195	224,804	31.24	7,388	271,066	36.69
Wyoming, Montana, Idaho	964	30,273	31.40	1,086	39,188	36.08
Colorado, Arizona, Utah, New Mexico	3,322	111,496	33.56	3,612	134,279	37.18
Washington	1,147	40,666	35.45	1,238	48,669	39.31
Oregon and Nevada	883	31,666	35.86	920	37,667	40.94
Northern California	2,362	77,073	32.63	2,357	92,016	39.04
Southern California	4,964	155,477	31.32	5,539	201,630	36.40
Hawaii	456	19,942	43.73	328	17,747	54.11
Puerto Rico	1,582	60,968	38.54	1,558	66,150	42.46
U.S. total or average[3] [4]	66,796	2,076,594	31.09	70,721	2,396,552	33.89
Foreign imports[5]	980	30,426	31.05	1,201	38,843	32.34
Total or average	67,776	2,107,020	31.09	71,922	2,435,395	33.86

[1]Includes data for white cement facilities (eight in 1975 and seven in 1976) as follows: Texas (three), Pennsylvania (two), one each in California and Wisconsin, and one in Florida for 1975; and for grinding plants (seven in 1975 and six in 1976), as follows: Wisconsin (two), Michigan (two), and one each in Florida, Pennsylvania (1975), and Virginia.

[2]Includes Puerto Rico.

[3]Data may not add to totals shown because of independent rounding.

[4]Includes cement produced from imported clinker.

[5]Cement imported and distributed by domestic producers only.

Table 3.—Portland cement production, capacity, and stocks in the United States, by district[1] [2]

(Thousand short tons)

District	1975					1976				
	Plants active during year	Production[3]	Capacity[4]		Stocks[5] at mills Dec. 31	Plants active during year	Production[3]	Capacity[4]		Stocks[5] at mills Dec. 31
			Finish grinding	Percent utilized				Finish grinding	Percent utilized	
New York and Maine	10	3,647	6,550	55.6	515	9	3,303	5,536	59.6	422
Eastern Pennsylvania	12	4,029	6,924	58.1	446	11	4,272	6,637	64.3	618
Western Pennsylvania	5	1,852	2,885	64.1	271	5	2,012	2,885	69.7	317
Maryland and West Virginia	4	1,849	2,842	65.0	199	4	1,897	2,821	67.2	245
Ohio	8	2,292	3,572	64.1	197	7	2,190	3,074	71.2	212
Michigan	8	4,634	7,543	61.4	691	8	5,118	7,543	67.8	689
Indiana, Kentucky, Wisconsin	10	3,032	4,926	61.5	356	9	3,338	5,058	65.9	323
Illinois	4	1,481	2,096	70.6	155	4	1,849	2,136	86.5	287
Tennessee	6	1,198	2,286	52.4	112	6	1,289	2,568	50.1	152
Virginia, North Carolina, South Carolina	6	2,396	4,804	49.8	237	6	2,486	4,804	51.7	257
Georgia	3	843	1,477	57.0	69	3	982	1,477	66.4	77
Florida	5	1,676	4,119	40.6	210	6	1,931	4,119	46.8	189
Alabama	7	1,995	2,781	71.7	214	7	2,098	3,115	67.3	223
Louisiana and Mississippi	6	1,330	2,648	50.2	123	5	1,551	2,193	70.7	130
Minnesota, South Dakota, Nebraska	4	1,479	2,197	67.3	139	3	1,484	1,915	77.4	158
Iowa	5	2,208	2,824	78.1	196	5	2,454	3,094	79.3	273
Missouri	7	3,919	5,150	76.1	387	7	4,334	5,171	83.8	376
Kansas	5	1,835	2,341	78.3	222	5	1,950	2,326	83.8	189
Oklahoma and Arkansas	5	2,232	3,452	64.6	253	5	2,620	3,462	75.6	253
Texas	18	7,074	9,940	71.1	471	18	7,438	9,711	76.5	543
Wyoming, Montana, Idaho	4	1,005	1,209	83.1	115	4	1,044	1,219	85.6	56
Colorado, Arizona, Utah, New Mexico	8	3,295	5,685	57.9	260	8	3,524	5,675	62.1	220
Washington	4	1,379	2,118	65.0	131	4	1,391	2,068	67.2	98
Oregon and Nevada	3	858	1,385	61.9	36	3	912	1,385	65.8	43
Northern California	4	2,214	3,229	68.5	218	4	2,377	3,026	78.5	152
Southern California	8	4,997	7,810	63.9	271	8	5,515	7,810	70.6	224
Hawaii	2	466	550	84.7	38	2	323	550	58.7	33
Puerto Rico	3	1,582	2,768	57.1	43	3	1,545	2,768	55.8	31
Total or average	174	[6]66,796	106,111	62.9	6,575	169	71,227	104,146	68.4	6,790

[1]Includes Puerto Rico.
[2]Includes data for white cement facilities (eight in 1975 and seven in 1976), as follows: Texas (three), Pennsylvania (two), one each in California and Wisconsin, and one in Florida for 1975; and for grinding plants (seven in 1975 and six in 1976), as follows: Wisconsin (two), Michigan (two), and one each in Florida, Pennsylvania (1975), and Virginia.
[3]Includes cement produced from imported clinker (1975—1,240; 1976—1,024).
[4]Grinding capacity based on fineness necessary to grind Types I and II cement, making allowance for downtime required for maintenance.
[5]Includes imported cement. Source of imports withheld to avoid disclosing individual company confidential data.
[6]Data do not add to total shown because of independent rounding.

Table 4.—Clinker capacity and production in the United States, by district, as of December 31, 1976[1] [2]

District	Active plants: Process used: Wet	Active plants: Process used: Dry	Active plants: Process used: Both	Active plants: Total	Number of kilns	Daily capacity (thousand short tons)	Average number of days for maintenance	Apparent annual capacity[3] (thousand short tons)	Production[4] (thousand short tons)	Percent utilized
New York and Maine	5	2	--	7	10	13.7	74	3,980	3,299	82.8
Eastern Pennsylvania	3	8	--	11	49	19.6	45	6,266	4,185	66.7
Western Pennsylvania	3	2	--	5	13	8.1	46	2,581	1,984	76.8
Maryland and West Virginia	2	2	--	4	10	8.1	67	2,415	1,856	76.8
Ohio	2	3	1	6	11	8.2	82	2,321	2,033	87.5
Michigan	5	1	--	6	17	18.1	50	5,705	4,947	86.7
Indiana, Kentucky, Wisconsin	3	4	--	7	14	12.0	50	3,783	3,084	81.5
Illinois	--	4	--	4	8	8.6	43	2,770	1,762	63.6
Tennessee	6	--	--	6	13	5.5	50	1,731	1,309	75.6
Virginia, North Carolina, South Carolina	3	2	--	5	14	12.7	55	3,933	2,318	58.9
Georgia	--	2	1	3	5	5.0	32	1,664	925	55.5
Florida	4	1	--	5	11	11.2	76	3,243	1,886	58.1
Alabama	3	2	1	6	16	8.5	111	2,161	2,161	100.0
Louisiana and Mississippi	4	--	--	4	8	5.5	57	1,694	1,452	85.7
Minnesota, South Dakota, Nebraska	2	--	1	3	9	4.6	55	1,425	1,333	93.5
Iowa	3	2	--	5	18	8.9	58	2,728	2,409	88.3
Missouri	5	2	--	7	12	15.4	65	4,623	4,263	92.2
Kansas	3	2	--	5	15	7.0	61	2,130	1,862	87.4
Oklahoma and Arkansas	3	2	--	5	11	8.6	48	2,726	2,536	93.0
Texas	13	3	2	18	47	27.4	63	8,263	7,346	88.9
Wyoming, Montana, Idaho	4	--	--	4	5	3.1	39	1,012	1,044	103.1
Colorado, Arizona, Utah, New Mexico	3	5	--	8	21	13.2	74	3,841	3,340	86.9
Washington	3	1	--	4	7	3.6	29	1,211	1,132	93.4
Oregon and Nevada	2	1	--	3	7	3.3	51	1,036	881	85.0
Northern California	2	2	--	4	13	9.2	81	2,612	2,213	84.7
Southern California	2	5	1	8	29	22.1	56	6,832	5,309	77.7
Hawaii	1	1	--	2	3	2.3	125	552	317	57.4
Puerto Rico	2	--	--	2	9	7.5	74	2,181	1,393	63.8
Total or average	91	59	7	157	405	281.0	61	85,419	68,579	80.2

[1]Includes Puerto Rico.
[2]Includes white-cement-producing facilities.
[3]Calculated on individual company data: 365 days, minus average days for maintenance, times the reported 24-hour capacity.
[4]Includes production reported for plants which added or shut down kilns during the year.

Table 5.—Daily clinker capacity, December 31[1] [2]

Short tons per 24-hour period	Number		Total capacity (short tons)	Percent of total capacity
	Plants	Kilns[3]		
1975:				
Less than 600	5	8	2,891	1.0
600 to 1,150	42	83	39,036	13.4
1,150 to 1,700	49	113	66,055	22.8
1,700 to 2,300	33	97	64,336	22.2
2,300 to 2,800	15	46	37,616	13.0
2,800 and over	20	88	80,124	27.6
Total	164	435	290,058	100.0
1976:				
Less than 600	7	8	2,891	1.0
600 to 1,150	37	70	32,067	11.4
1,150 to 1,700	47	116	68,375	24.4
1,700 to 2,300	29	81	57,117	20.3
2,300 to 2,800	14	44	34,831	12.4
2,800 and over	23	86	85,755	30.5
Total	157	405	281,036	100.0

[1]Includes Puerto Rico.
[2]Includes white-cement-producing facilities.
[3]Total number in operation at plants.

Table 6.—Raw materials used in producing portland cement in the United States[1]

(Thousand short tons)

Raw materials	1975	1976
Calcareous:		
Limestone (includes aragonite)	76,414	[2]81,342
Cement rock (includes marl)	17,869	20,159
Oystershell	3,006	2,390
Argillaceous:		
Clay	6,659	7,009
Shale	3,447	3,655
Other (includes staurolite, bauxite, aluminum dross, pumice, and volcanic material)	208	187
Siliceous:		
Sand	1,813	1,985
Sandstone and quartz	582	707
Ferrous: Iron ore, pyrites, millscale, and other iron-bearing material	772	825
Other:		
Gypsum and anhydrite	3,527	3,658
Blast furnace slag	465	435
Fly ash	180	264
Other, n.e.c	2	8
Total	114,944	122,624

[1]Includes Puerto Rico.
[2]Includes marble.

MASONRY CEMENT

Shipments of masonry cement totaled 3.3 million tons in 1976, an increase of 13.6% compared with those of 1975, but still 20% less than the record shipments of 1973. The average unit price was $42.63 per ton, a 9.6% increase compared with that of 1975. Total value of masonry cement shipments increased to $141 million, nearly 25% above the value of 1975 shipments. By yearend, 111 plants manufactured masonry cement in the United States. Four plants produced masonry cement exclusively, as follows: Cheney Lime & Cement Co., Allgood, Ala.; G. & W. H. Corson, Inc., Plymouth Meeting, Pa.; Campbell-Grove Div. of The Flintkote Co., Frederick, Md.; and Riverton Corp., Riverton, Va. Martin Marietta Corp. ceased production of masonry cement at its North Birmingham, Ala., plant at yearend 1975. Masonry cement was not produced in some parts of the country because many of the masons preferred to use portland cement and add clay or lime to provide the necessary plasticity.

Table 7.—Masonry cement shipped by producers in the United States, by district[1]

(Thousand short tons and thousand dollars)

District	1975 Quantity	1975 Value	1975 Average per ton	1976 Quantity	1976 Value	1976 Average per ton
New York and Maine	90	2,721	$30.23	86	2,828	$32.88
Eastern Pennsylvania	221	9,562	43.27	240	11,581	48.25
Western Pennsylvania	136	5,078	37.34	139	5,322	38.29
Maryland and West Virginia	101	3,301	32.68	124	4,317	34.81
Ohio	136	4,576	33.65	155	7,288	47.02
Michigan	183	6,429	35.13	218	8,370	38.39
Indiana, Illinois, Kentucky, Wisconsin	484	18,638	38.51	560	22,377	39.96
Tennessee	138	4,778	34.62	175	6,476	37.01
Virginia, North Carolina, South Carolina	281	12,781	45.48	300	13,863	46.21
Georgia and Florida	170	7,723	45.43	176	8,177	46.46
Alabama	262	10,253	39.13	314	13,671	43.54
Louisiana and Mississippi	43	1,441	33.51	53	2,013	37.98
Minnesota, South Dakota, Nebraska	33	1,385	41.97	31	1,523	49.13
Iowa	62	2,933	47.31	76	4,143	54.51
Missouri	65	2,110	32.46	76	2,718	35.76
Kansas	57	2,311	40.54	72	3,281	45.57
Oklahoma and Arkansas	108	3,912	36.22	124	5,015	40.44
Texas	181	7,089	39.17	213	10,596	49.75
Wyoming, Montana, Idaho	7	273	39.00	9	406	45.11
Colorado, Arizona, Utah, New Mexico	89	3,459	38.87	106	4,507	42.52
Washington	5	209	41.80	6	334	55.68
Oregon and Nevada; Northern California; Southern California	2	74	37.00	2	96	48.00
Hawaii	13	762	58.62	11	663	60.27
U.S. total or average[2]	2,868	111,800	38.99	3,266	139,564	42.73
Foreign imports[3]	40	1,308	32.70	38	1,291	33.97
Total or average	2,908	113,108	38.90	3,304	140,855	42.63

[1]Does not include quantities produced on the job by masons.
[2]Data may not add to totals shown because of independent rounding.
[3]Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing individual company confidential data.

Table 8.—Masonry cement production and stocks in the United States, by district

(Thousand short tons)

District	1975 Plants active during year	1975 Production	1975 Stocks[1] at mills Dec. 31	1976 Plants active during year	1976 Production	1976 Stocks[1] at mills Dec. 31
New York and Maine	6	90	12	5	82	7
Eastern Pennsylvania	10	219	27	9	246	36
Western Pennsylvania	5	138	18	5	140	20
Maryland and West Virginia	3	101	4	3	135	7
Ohio	5	137	12	4	157	15
Michigan	5	220	79	5	214	72
Indiana, Illinois, Kentucky, Wisconsin	7	483	48	7	563	53
Tennessee	5	154	15	5	195	22
Virginia, North Carolina, South Carolina	5	282	19	5	301	20
Georgia and Florida	4	147	22	5	167	27
Alabama	7	266	31	7	312	27
Louisiana and Mississippi	3	36	3	3	44	3
Minnesota, South Dakota, Nebraska	4	38	12	3	22	5
Iowa	3	69	15	3	74	13
Missouri	4	66	13	4	70	8
Kansas	5	66	22	5	70	18
Oklahoma and Arkansas	5	107	6	5	126	7
Texas	12	189	21	12	220	19
Wyoming, Montana, Idaho	4	8	4	3	11	5
Colorado, Arizona, Utah, New Mexico	6	90	11	6	103	8
Washington	4	6	2	4	5	1
Oregon and Nevada	--	--	(2)	--	--	(2)
Northern California	--	--	(2)	--	--	(2)
Southern California	1	(2)	(2)	1	1	--
Hawaii	2	13	2	2	10	2
Total	115	[3]2,925	398	111	[3]3,268	395

[1]Includes imported cement.
[2]Less than 500 short tons.
[3]Includes 2,185,000 tons produced from clinker, and 739,000 tons produced from cement (1975); 2,597,000 tons produced from clinker, and 671,000 tons produced from cement (1976).

ALUMINOUS CEMENT

Aluminous cement, also known as calcium aluminate cement, high-alumina cement, and "Ciment Fondu," is a nonportland hydraulic cement. It was produced at the following three plants in the United States: United States Steel Corp., Universal Atlas Cement Div., Buffington, Ind.; Lone Star Lafarge Co. at Chesapeake, Va.; and Aluminum Co. of America at Bauxite, Ark.

As discussed previously, Lone Star Lafarge announced plans to build a new calcium aluminate cement manufacturing plant at its Chesapeake, Va., site. Primary use of the product will be in refractory castables and in metallurgical and petroleum manufacturing operations.

ENERGY

The cement industry has the highest ratio of energy costs to total material costs found in any manufacturing process. The availability of economical and continuing supplies of energy has become one of the cement industry's principal concerns. Rising prices and interruptible supplies of fuels necessitated efforts to increase energy efficiency and convert to available lower cost sources. New technology, which incorporates energy-saving preheater systems, is being used in both new plant installations and modernization projects. The preheater systems are being installed in increasing numbers with precalcining stages that, in addition to heating the raw materials with kiln exhaust gases, actually start the calcining reaction by applying heat to the feed before it enters the kiln. In this way, kiln length can be reduced, with less heat dissipated into the atmosphere.

Conversions to alternate sources of energy from scarce and expensive natural gas generally involved coal or petroleum coke, depending upon availability. Cement plants that converted from gas to coal during 1976 included the following: Martin Marietta Cement Corp. Western Div., Tulsa, Okla.; Ideal Basic Industries, Inc. Cement Div., Ada, Okla.; OKC Corp., Oklahoma Cement Co. Div. at Pryor, Okla.; Kaiser Cement & Gypsum Corp., San Antonio, Tex.; and Centex Corp., Nevada Cement Co., Fernley, Nev. In other changes, San Antonio Portland Cement Co. converted two kilns to petroleum coke at its Cementville, Tex., plant. The Louisiana Cement Co. plant of OKC Corp. at New Orleans, La., and the Santa Cruz plant of Lone Star Industries, Inc., at Davenport, Calif., converted from natural gas to fuel oil as their principal fuel. In another fuel-related change, Florida Mining & Materials Corp. installed a new coal mill at its Tampa, Fla., plant. Several additional companies were considering changeovers to either coal or petroleum coke.

By 1976, a number of cement-producing companies possessed their own coal properties, including Marquette Cement Manufacturing Co., which acquired coal properties in 1974; Medusa Corp., which began strip-mining coal in 1975; National Cement Co., Inc.; Texas Industries, Inc.; United Cement Co.; California Portland Cement Co.; Ideal Basic Industries, Inc., through its subsidiary, Union Pacific Corp.; and Amcord, Inc. Since 1975, Amcord, through its coal operations known as Amcoal with holdings in New Mexico, had been seeking to obtain coal mining operations in Pennsylvania and also looking for deposits in Utah and California.[6]

In 1976, total energy from fossil fuels consumed by the cement industry in clinker manufacture was about 410 trillion Btu, equivalent to 0.6% of the total energy used in the United States. Of this amount, 215 trillion Btu was derived from coal; 136 trillion Btu, from natural gas; 50 trillion Btu, from fuel oil; and 9 trillion Btu, from petroleum coke. Total consumption of coal by the industry was 23% more than it had been in 1975, reflecting the trend to coal as the primary kiln fuel. Consumption by the cement industry of natural gas decreased 27 billion cubic feet, a 17% reduction in usage compared with that of 1975.

Energy from fossil fuels consumed in cement plants to produce clinker averaged 5.8 million Btu per ton in 1976, ranging from 11.7 million to 3.4 million Btu per ton. These figures show only a very slight improvement compared with those of 1975, when the average was 6.05 million Btu per ton, ranging from 11.8 million to 3.5 million Btu per ton.

[6]Amcord, Inc. Summary of the 1976 Annual Meeting. May 11, 1976, 10 pp.

Wet-process plants were the least energy efficient. Average consumption nationwide was 6.4 million Btu per ton, whereas the average for dry-process kilns was 5.2 million Btu per ton. Small wet-process kilns were the most inefficient; however, some of the larger wet-process kilns produced clinker with less energy than at many dry-process plants. There was a less direct relationship between kiln capacity and efficiency among dry-process plants than among wet-process plants. Kilns without preheaters averaged 6.1 million Btu per ton; those with suspension preheaters averaged 4.6 million and those with grate-type preheaters averaged 5.8 million Btu per ton of clinker produced.

Electrical energy consumed in the manufacture of cement totaled 10 billion kilowatt-hours, 9.5 billion of which was purchased commercially and 0.5 billion was generated on site. The average amount of electrical energy used to produce 1 ton of cement was 141.5 kilowatt-hours, 1 kilowatt-hour less than that required in 1975. This energy, used principally for grinding operations, added nearly another 0.5 Btu of energy required to manufacture 1 ton of cement. (This is based on 3,412 Btu per kilowatt-hour instead of 10,660 Btu, as used in the 1975 Minerals Yearbook chapter on Cement). The resulting 1976 total energy requirement, onsite, to produce portland and masonry cement averaged about 6.3 million Btu per ton.

Gains in energy efficiency that have been achieved during the last few years are largely due to reduction in kiln feed moisture content and improved heat transfer in the kiln through installation of chains.[7] In some plants, lowered operating rates, because of poor market conditions, worked to offset these gains.

Another means of conserving energy which has not yet achieved wide use is the incorporation of pozzolanic additives. Several plants have increased the use of fly ash and slag in the production of Type IP, portland-pozzolan cement, and Type IS, portland-blast-furnace-slag cement. However, the proportion of total shipments has remained constant or decreased in the last few years. In 1976, shipments of Type IP and Type IS were 344,000 tons, less than 0.5% of total portland cement shipments. This ratio is virtually the same as in 1975, and only about half of the relative amount shipped in 1974. In 1976, the boom cement year, Types IP and IS commanded 1.2% of the market. It is expected that energy considerations will provide impetus for greater future use of pozzolanic additives.

The use of municipal refuse as a kiln fuel was being investigated and put into practice in Europe. It is not expected to emerge as a significant fuel source in the United States for some time to come, owing to incompatibility with present feed mechanisms, transportation, and storage systems, and possible adverse effect on clinker quality in existing kiln systems.[8]

Studies were being proposed in Canada to investigate replacing conventional fuels for kiln operation with low-Btu substitutes, such as garbage, used oil, lignite, and tar sands.[9]

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[7]Portland Cement Association. Progress Report No. 3. April 1976, p. 37.

[8]Dorn, J. D. Can Municipal Refuse Fuel Cement Kilns? Pit & Quarry, v. 69, No. 5, November 1976, pp. 46-49, 78.

[9]Western Miner. V. 49, No. 11, November 1976, pp. 31-32.

Table 9.—Clinker produced in the United States, by kind of fuel[1]

Year and fuel	Clinker produced			Fuel consumed		
	Plants active during year	Quantity (thousand short tons)	Percent of total	Coal[2] (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1975:						
Coal	36	[3]14,101	21.9	3,326	--	--
Oil	9	[3]3,289	5.0	--	3,083	--
Natural gas	18	[3]5,709	8.9	--	--	36,336,640
Coal and oil	21	8,887	13.8	1,651	1,743	--
Coal and natural gas	42	14,568	22.6	2,006	--	46,343,576
Oil and natural gas	27	11,569	17.9	--	1,863	59,972,545
Coal, oil, natural gas	15	6,416	9.9	585	642	16,907,095
Total	168	64,539	100.0	7,568	7,331	159,559,856
1976:						
Coal	38	[3]16,447	24.0	3,773	--	--
Oil	7	[3]2,497	3.6	--	2,322	--
Natural gas	12	[3]4,304	6.3	--	--	26,617,431
Coal and oil	21	9,487	13.8	1,920	1,026	--
Coal and natural gas	42	16,708	24.4	2,492	--	45,568,090
Oil and natural gas	27	13,069	19.1	--	3,928	53,376,632
Coal, oil, natural gas	14	6,067	8.8	1,103	330	6,657,355
Total	161	68,579	100.0	9,288	7,606	132,219,508

[1]Includes Puerto Rico.
[2]Includes 0.1% anthracite, 94.7% bituminous, and 5.2% petroleum coke in 1975; and 96.5% bituminous and 3.5% petroleum coke in 1976.
[3]Average consumption of fuel per ton of clinker produced as follows: 1975—coal, 0.23587 ton; oil, 0.937 barrel; and natural gas, 6,365 cubic feet. 1976—coal, 0.22940 ton; oil, 0.930 barrel; and natural gas, 6,184 cubic feet.

Table 10.—Clinker produced and fuel consumed by the portland cement industry in the United States, by process[1]

Year and process	Clinker produced			Fuel consumed		
	Plants active during year	Quantity (thousand short tons)	Percent of total	Coal[2] (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1975:						
Wet	98	36,413	56.4	4,215	5,554	104,983,678
Dry	64	25,179	39.0	3,182	1,681	42,973,033
Both	6	2,947	4.6	171	96	[r]11,603,145
Total	168	64,539	100.0	7,568	7,331	[r]159,559,856
1976:						
Wet	93	37,980	55.4	5,050	5,508	88,107,261
Dry	61	26,720	39.0	3,947	1,347	35,245,967
Both	7	3,879	5.6	291	751	8,866,280
Total	161	68,579	100.0	9,288	7,606	132,219,508

[r]Revised.
[1]Includes Puerto Rico.
[2]Includes 0.1% anthracite, 94.7% bituminous, and 5.2% petroleum coke in 1975; and 96.5% bituminous and 3.5% petroleum coke in 1976.

Table 11.—Electric energy used at portland cement plants in the United States, by process[1] [2]

Year and process	Electric energy used: Generated at portland cement plants: Active plants	Generated at portland cement plants: Quantity (million kilowatt-hours)	Purchased: Active plants	Purchased: Quantity (million kilowatt-hours)	Total: Quantity (million kilowatt-hours)	Total: Percent	Finished cement produced (thousand short tons)	Average electric energy used per ton of cement produced (kilowatt-hours)
1975:								
Wet	4	115	96	4,958	5,073	53.3	37,598	134.9
Dry[3]	6	523	70	3,497	4,020	42.2	26,248	153.2
Both	--	--	6	426	426	4.5	2,949	144.4
Total	10	638	172	8,881	9,519	100.0	[4]66,796	142.5
Percent of total electric energy used	--	6.7	--	93.3	--	--	--	--
1976:								
Wet	3	77	92	5,158	5,235	51.9	39,757	131.7
Dry[3]	6	493	66	3,784	4,277	42.4	27,807	153.8
Both	--	--	7	569	569	5.7	3,663	155.3
Total	9	570	165	9,511	10,081	100.0	71,227	141.5
Percent of total electric energy used	--	5.6	--	94.4	--	--	--	--

[1]Includes grinding plants and white cement facilities.
[2]Includes Puerto Rico.
[3]Includes data for grinding plants, seven in 1975; six in 1976.
[4]Data do not add to total shown because of independent rounding.

TRANSPORTATION

Trucks hauled most of the cement delivered to customers in the United States; railroads and barges transported most cement shipments from manufacturing plants to distribution terminals. Trucks hauled 86.5% of the cement shipped to customers, railroads handled 11.5%, and 2% was transported by waterway. This represented very little change from 1975. Compared with those of 1975, barge shipments increased 58%, railroad shipments decreased 3%, and shipments by truck increased 6%.

Table 12.—Shipments of portland cement from mills in the United States, in bulk and in containers, by type of carrier[1]

(Thousand short tons)

Year and type of carrier	Shipments from plant to terminal		Shipments to ultimate consumer				Total shipments
			From terminal to consumer		From plant to consumer		
	In bulk	In containers	In bulk	In containers	In bulk	In containers	
1975:							
Railroad	7,023	199	940	121	7,214	259	8,534
Truck	775	79	14,241	831	39,035	4,354	58,461
Barge and boat	7,485	17	36	--	641	--	677
Unspecified[2]	--	--	--	--	99	3	102
Total	15,283	295	15,217	952	46,989	4,616	[3] [4]67,776
1976:							
Railroad	8,054	204	746	22	7,259	254	8,281
Truck	1,282	151	16,389	977	40,077	4,808	62,251
Barge and boat	7,333	15	464	--	609	--	1,073
Unspecified[2]	260	--	204	--	102	10	316
Total	16,929	370	17,803	999	48,047	5,072	[3] [4]71,922

[1]Includes Puerto Rico.
[2]Includes cement used at plant.
[3]Bulk shipments were 92.0% (62,206,000 tons), and container (bag) shipments were 8.0% (5,568,000 tons) for 1975. Bulk shipments were 92.0% (65,850,000 tons), and container (bag) shipments were 8.0% (6,071,000 tons) for 1976.
[4]Data do not add to totals shown because of independent rounding.

Table 13.—Cement shipments, by destination and origin[1]

(Thousand short tons)

	Portland cement[2]		Masonry cement	
	1975	1976	1975	1976
Destination:				
Alabama	1,146	1,376	97	117
Alaska[3]	131	134	W	W
Arizona	1,086	1,111	W	W
Arkansas	802	885	64	69
California, northern	2,651	2,734	--	--
California, southern	4,196	4,569	1	--
Colorado	1,162	1,197	24	30
Connecticut[3]	624	568	13	14
Delaware[3]	122	142	7	7
District of Columbia[3]	247	196	9	8
Florida	3,190	3,347	214	222
Georgia	1,542	1,614	143	166
Hawaii	463	328	13	10
Idaho	393	511	3	2
Illinois	3,281	3,760	101	117
Indiana	1,543	1,700	98	116
Iowa	1,739	1,800	26	32
Kansas	1,122	1,229	26	34
Kentucky	893	1,046	95	118
Louisiana	2,191	2,486	59	79
Maine	274	308	11	11
Maryland	1,106	1,188	90	101
Massachusetts[3]	914	811	34	35
Michigan	2,344	2,596	131	139
Minnesota	1,474	1,551	45	50
Mississippi	813	830	56	66
Missouri	1,635	1,723	39	50
Montana	253	335	3	4
Nebraska	899	1,029	14	18
Nevada	366	359	(4)	(4)
New Hampshire[3]	209	236	11	13
New Jersey[3]	1,443	1,366	51	54
New Mexico	540	543	15	16
New York, eastern	584	745	26	26
New York, western	905	872	45	43
New York, metropolitan[3]	1,070	866	33	32
North Carolina	1,357	1,459	194	220
North Dakota[3]	372	412	8	10
Ohio	2,848	2,804	179	188
Oklahoma	1,186	1,262	49	61
Oregon	774	794	1	1
Pennsylvania, eastern	1,760	1,756	67	75
Pennsylvania, western	1,014	1,102	79	91
Puerto Rico	1,470	1,433	--	(4)
Rhode Island[3]	140	142	5	5
South Carolina	800	782	109	119
South Dakota	313	373	9	10
Tennessee	1,326	1,309	153	172
Texas	6,130	6,469	158	194
Utah	691	920	1	2
Vermont[3]	109	109	5	5
Virginia	1,602	1,599	154	182
Washington	1,032	1,168	7	9
West Virginia	568	579	41	51
Wisconsin	1,551	1,602	54	67
Wyoming	317	418	3	5
Total United States	68,713	72,583	2,873	3,266
Foreign countries[5]	365	250	56	63
Total shipments	69,078	72,833	2,929	3,329
Origin:				
United States[6]	65,230	69,171	2,869	3,266
Puerto Rico	1,566	1,550	--	--
Foreign:[7]				
Domestic producers	980	1,201	39	38
Others	1,302	911	21	25
Total shipments	69,078	72,833	2,929	3,329

W Withheld to avoid disclosing individual company confidential data; included with "Foreign countries."
[1]Includes cement produced from imported clinker and imported cement shipped by domestic producers, Canadian cement manufacturers, and other importers. Includes Puerto Rico.
[2]Excludes cement (1975—384; 1976—397) used in the manufacture of prepared masonry cement.
[3]Has no cement-producing plants.
[4]Less than 500 short tons.
[5]Direct shipments by producers to foreign countries and U.S. possessions and territories; includes States indicated by symbol W.
[6]Includes cement produced from imported clinker by domestic producers (1975—1,240; 1976—1,024).
[7]Imported cement distributed by domestic producers, Canadian cement manufacturers, and other importers. Origin of imports withheld to avoid disclosing individual company confidential data.

Table 14.—Portland cement shipments in 1976, by type of customer[1]

(Thousand short tons)

District origin	Building material dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal, State, and other government agencies		Miscellaneous including own use		Total[2]
	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	
New York and Maine	321	8.6	557	15.0	2,725	73.2	92	2.4	28	0.8	--	--	--	--	3,723
Eastern Pennsylvania	445	11.0	996	24.6	2,341	57.9	161	4.0	73	1.8	4	0.1	24	0.6	4,045
Western Pennsylvania	183	9.4	295	15.2	1,180	60.7	259	13.3	22	1.1	--	--	5	.3	1,945
Maryland and West Virginia	118	6.5	441	24.3	1,175	64.6	26	1.4	47	2.6	10	.6	1	(3)	1,818
Ohio	149	7.0	395	18.5	1,457	68.4	112	5.3	5	.2	--	--	13	.6	2,130
Michigan	245	5.0	708	14.3	3,151	63.9	744	15.1	70	1.5	13	.2	--	--	4,931
Indiana, Kentucky, Wisconsin	234	7.0	614	18.5	2,043	61.4	336	10.0	75	2.3	5	.1	22	.7	3,328
Illinois	73	4.5	112	6.9	1,094	67.0	338	20.7	14	.9	--	--	1	(3)	1,632
Tennessee	107	8.5	277	22.1	763	60.8	28	2.2	11	.9	61	4.9	8	.6	1,256
Virginia, North Carolina, South Carolina	155	6.1	393	15.4	1,823	71.6	134	5.3	34	1.3	4	.2	3	.1	2,546
Georgia	99	10.7	135	14.5	525	56.5	131	14.1	37	4.0	2	.2	--	--	930
Florida	202	10.4	382	19.6	1,064	54.6	158	8.1	121	6.2	12	.6	9	.5	1,949
Alabama	168	7.9	397	18.6	1,248	58.5	130	6.1	180	8.4	8	.4	3	.1	2,134
Louisiana and Mississippi	147	9.8	87	5.8	862	57.2	101	6.7	198	13.1	73	4.8	40	2.6	1,508
Minnesota, South Dakota, Nebraska	82	5.6	138	9.4	863	58.6	365	24.7	18	1.2	3	.2	5	.3	1,473
Iowa	108	4.4	483	19.8	1,619	66.4	194	8.0	14	.6	1	(3)	19	.8	2,438
Missouri	102	2.3	418	9.6	3,236	74.4	548	12.6	42	1.0	--	--	6	.1	4,353
Kansas	125	6.2	156	7.8	1,369	68.3	140	7.0	104	5.2	--	--	111	5.5	2,005
Oklahoma and Arkansas	166	6.5	249	9.8	1,492	58.5	476	18.7	100	3.9	2	(3)	65	2.6	2,551
Texas	537	7.3	736	10.0	4,620	62.5	303	4.1	834	11.3	74	1.0	283	3.8	7,388
Wyoming, Montana, Idaho	32	2.9	68	6.3	757	69.7	28	2.6	150	13.8	7	.6	45	4.1	1,086
Colorado, Arizona, Utah, New Mexico	189	5.2	369	10.2	2,458	68.1	258	7.2	181	5.0	4	.1	153	4.2	3,612
Washington	67	5.4	188	15.2	848	68.5	51	4.1	42	3.4	5	.4	38	3.0	1,238
Oregon and Nevada	77	8.4	105	11.4	617	67.1	97	10.5	20	2.2	1	.1	3	.3	920
Northern California	234	9.9	277	11.8	1,607	68.2	102	4.3	111	4.7	2	.1	24	1.0	2,357
Southern California	532	9.6	705	12.7	3,884	70.1	154	2.8	176	3.2	16	.3	72	1.3	5,539
Hawaii	20	6.0	33	10.0	265	80.7	6	1.8	3	.9	--	--	2	.6	328
Puerto Rico	559	35.9	198	12.7	615	39.5	118	7.6	46	2.9	19	1.2	3	.2	1,558
Imports[4]	21	1.8	161	13.4	965	80.3	32	2.7	16	1.3	--	--	7	.5	1,201
Total or average	5,497	7.6	10,073	14.0	46,666	64.9	5,622	7.8	2,772	3.9	326	.5	965	1.3	71,922

[1]Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 0.1%.
[4]Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing individual company confidential data.

Table 15.—Portland cement shipped from plants in the United States, by type[1]

(Thousand short tons and thousand dollars)

Type	1975 Quantity	1975 Value[2]	1975 Average per ton	1976 Quantity	1976 Value[2]	1976 Average per ton
General use and moderate heat (Types I and II)	62,816	1,924,202	$30.63	66,598	2,222,426	$33.37
High-early-strength (Type III)	2,107	69,085	32.79	2,217	77,013	34.74
Sulfate-resisting (Type V)	346	12,236	35.36	279	10,567	37.87
Oil well	1,120	37,249	33.26	1,275	46,765	36.68
White	365	27,323	74.86	362	31,359	86.63
Portland slag and portland pozzolan	315	9,584	30.43	344	10,760	31.28
Expansive	92	3,856	41.91	97	4,243	43.74
Miscellaneous[3]	617	23,484	38.06	750	32,262	43.02
Total or average	[4]67,776	[4]2,107,020	31.09	71,922	2,435,395	33.86

[1]Includes Puerto Rico.

[2]Mill value is the actual value of sales to customers, f.o.b. plant, less all discounts and allowances, less all freight charges to customer, less all freight charges from producing plant to distribution terminal if any, less total cost of operating terminal if any, less cost of paper bags and pallets.

[3]Includes waterproof cement and low-heat (Type IV) (1975-76) and regulated fast setting (1975).

[4]Data do not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Shipments of cement into various States are considered to be an index of consumption. Portland cement consumption increased 6% above that of 1975. Domestic producers shipped 71.9 million tons of portland cement, which included 1.2 million tons of imported cement. In addition to the imported cement shipped by domestic manufacturers, 911,000 tons of portland cement was imported and shipped or used by others not producing cement in the United States or Puerto Rico.

Consumption increased in all but 11 States, the District of Columbia, and Puerto Rico. The greatest regional reduction in usage was in the New York City metropolitan area, and the State showing the largest drop was Hawaii, where shipments were down 29%. Other large decreases in consumption were in the Northeast United States as follows: District of Columbia, 21%; Massachusetts, 11%; Connecticut, 9%; and New Jersey, 5%. The largest increase in consumption was in Illinois, where shipments were up 479,000 tons, a 15% increase over those of 1975. The second largest increase was in California, where consumption increased 456,000 tons compared with that of 1975. Next in order of increased consumption were Texas and Louisiana, where shipments increased 339,000 and 295,000 tons, respectively. Alabama and Utah each increased consumption by about 230,000 tons.

Ready-mix concrete producers were the primary consumers of portland cement, accounting for 65% of the total quantity shipped by domestic producers. Manufacturers of concrete products used 14% of the cement to make concrete blocks and pipe, precast-prestressed concrete, and other concrete products. Highway contractors and building materials dealers each received 8% of the total cement consumed; other contractors received 4%; and Federal, State, and other government agencies, and other miscellaneous users consumed the remaining 1% to 2%.

PRICES

The average mill value[10] of all types of portland cement was $33.86 per ton in 1976, $2.77 per ton higher than in 1975. The mill values ranged from a low of $27.58 in New York and Maine to highs of $40.94 in Oregon and Nevada, $42.46 in Puerto Rico, and $54.11 in Hawaii.

According to Engineering News-Record, December bulk mill prices ranged from

[10]Mill value is the actual value of sales to customers f.o.b. plant, less all discounts and allowances, less all freight charges to customer, less all freight charges from producing plant to distribution terminal if any, less total cost of operating terminal if any, less cost of paper bags and pallets.

$28.80 in Louisville, Ky., to $57.60 in Waianae, Hawaii. The highest price in the continental United States was $48.40 per ton at Redding, Calif. Bagged cement prices were $6.00 to $11.00 per ton higher than bulk prices, and all prices were subject to cash discounts. The area price for bulk cement reached a high of $82.20 per ton in Anchorage, Alaska. Base prices for portland cement in carload lots f.o.b. were reported monthly in Engineering News-Record for 20 cities in the United States. The December 1976 average price for bulk cement was $41.06 per ton, compared with $37.50 per ton in December 1975. Bulk prices in the 20 cities ranged from $34.60 in Detroit to $46.80 in Los Angeles.

Table 16.—Average mill value in bulk, of cement in the United States[1]

(Per short ton)

Year	Portland cement	Prepared masonry cement[2]	All classes of cement
1972	$20.31	$26.52	$20.59
1973	21.88	29.43	22.23
1974	26.52	32.93	26.79
1975	31.09	38.90	31.41
1976	33.86	42.63	34.25

[1]Includes Puerto Rico.
[2]Masonry cement made at cement plants only.

FOREIGN TRADE

Hydraulic cement exported from the United States decreased 5.7% in quantity and 6.4% in value from that of 1975. Exported cement was equivalent to 0.7% of domestic shipments by quantity and 1.1% of their value. Six countries—Canada, Mexico, Venezuela, Leeward and Windward Islands, the Dominican Republic, and Ecuador—received nearly 95% of the 466,000 tons of cement valued at $26,601,000, which was exported to 87 countries.

Hydraulic cement and clinker imported into the United States decreased 16% in quantity, while the value decreased only 5% from that of 1975. Imported cement amounted to 4.2% of domestic shipments by weight and 2.7% of the value.

Canada continued to supply the largest amount of imported cement and clinker, providing 58% of the total, followed by the Bahamas and Spain, with 9% each, Norway, 8%; France and Mexico, each 5%.

Clinker comprised 31% of the total imports in 1976, compared with 28% in 1975, 32% in 1974, and 41% in 1973. Two plants operated exclusively on imported clinker, and an additional nine supplemented cement production by grinding imported clinker.

Table 17.—U.S. exports of hydraulic cement, by country

Country	1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Afghanistan	--	--	661	$31	--	--
Austria	152	$37	4,671	147	205	$57
Australia	269	32	212	87	581	151
Bahamas	4,184	230	1,666	135	1,455	121
Belgium-Luxembourg	169	43	391	71	1,167	168
Belize	483	26	269	14	110	14
Bermuda	75	20	49	12	72	25
Brazil	120	47	2,117	185	702	112
Canada	125,824	6,008	274,236	16,105	218,932	15,995
Colombia	55	17	10	10	1,111	66
Chile	108	19	22	14	242	54
Costa Rica	51	17	77	71	30	12
Dominican Republic	48,941	1,072	34,862	788	8,508	361
Ecuador	751	53	428	73	5,534	300
Egypt	3	2	222	17	--	--
El Salvador	21	3	351	25	79	21
France	131	33	165	43	161	52
French West Indies	1,086	23	728	19	290	17
Germany, West	103	30	105	44	404	116
Ghana	705	41	--	--	23	5
Guatemala	1,576	122	578	55	849	89
Haiti	1,005	27	37	10	1,973	105
Honduras	68	15	29	10	63	17
Hong Kong	100	19	124	30	40	40
Indonesia	1,721	95	3,061	2,407	336	57
Iran	46	18	39	53	45	33
Ireland	129	20	84	18	36	6
Italy	700	99	949	140	640	159
Jamaica	10,153	296	1,221	184	418	128
Japan	2,207	661	1,075	313	844	276
Korea, Republic of	86	28	143	63	53	13
Kuwait	16	11	12	11	83	35
Leeward and Windward Islands	15,419	308	23,498	651	24,148	655
Libya	248	16	11	17	313	214
Mexico	38,765	3,018	108,503	3,910	127,803	3,625
Morocco	--	--	811	58	--	--
Netherlands Antilles	16,067	334	6,791	212	4,057	123
Nicaragua	349	44	413	36	50	22
Niger	998	56	470	33	--	--
Norway	26	21	15	15	14	23
Panama	243	47	49	15	1,746	138
Peru	4,182	275	3,119	368	2,165	183
Philippines	1,710	151	67	18	313	95
Saudi Arabia	737	100	1,540	243	732	306
Singapore	5,126	244	126	35	180	86
South Africa, Republic of	118	30	168	59	476	72
Spain	119	30	114	63	135	55
Sweden	261	91	82	48	48	19
Switzerland	173	75	170	51	151	57
Taiwan	251	163	359	113	214	38
Trinidad and Tobago	82	29	62	94	49	16
Trust Territory of the Pacific Islands	60	3	354	17	72	5
Turkey	1	(1)	20	24	58	29
Turks and Caicos Islands	--	--	--	--	644	34
United Kingdom	434	91	338	120	426	121
Venezuela	985	202	16,120	589	56,178	1,527
Yugoslavia	348	87	552	142	101	24
Zaire	--	--	763	45	--	--
Other	2,104	281	1,023	248	996	529
Total	289,844	14,860	494,132	28,409	466,055	26,601

[1]Less than 1/2 unit.

Table 18.—U.S. imports for consumption of hydraulic and clinker cement, by country

(Thousand short tons and thousand dollars)

Country	1975		1976	
	Quantity	Value	Quantity	Value
Bahamas	349	9,229	242	6,195
Belgium-Luxembourg	14	722	14	750
Canada	1,819	33,951	1,801	38,833
Colombia	2	64	--	--
Denmark	15	413	(1)	1
France	312	6,237	178	5,279
Germany, West	30	491	(1)	48
Honduras	4	104	--	--
Italy	--	--	(1)	1
Japan	28	639	6	139
Mexico	148	2,535	175	3,678
Norway	365	6,127	265	4,410
Spain	301	4,602	314	5,630
Sweden	99	1,748	20	361
United Kingdom	214	3,629	90	1,590
Yugoslavia	2	129	2	170
Total	3,702	70,620	3,107	67,085

[1]Less than 1/2 unit.

Table 19.—U.S. imports for consumption of cement

(Thousand short tons and thousand dollars)

Year	Roman, portland and other hydraulic cement		Hydraulic cement clinker		White nonstaining portland cement		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1974	3,870	73,315	1,829	26,737	33	1,682	5,732	101,734
1975	2,474	49,286	1,207	20,218	21	1,116	3,702	70,620
1976	2,122	46,635	962	19,136	23	1,314	3,107	67,085

Table 20.—U.S imports for consumption of hydraulic and clinker cement, by customs district and country

(Thousand short tons and thousand dollars)

Customs district and country	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Anchorage:				
Canada	63	2,037	33	1,105
Japan	(1)	2	(1)	3
Total	63	2,039	33	1,108
Baltimore: Germany, West	(1)	7	--	--
Boston: Spain	18	143	--	--
Buffalo:				
Canada	582	10,491	515	11,260
Germany, West	(1)	5	(1)	3
Total	582	10,496	515	11,263
Chicago: Canada	27	526	--	--
Cleveland: Canada	33	816	30	621
Detroit:				
Canada	414	7,386	525	10,336
France	(1)	(1)	--	--
United Kingdom	--	--	(1)	(1)
Total	414	7,386	525	10,336
Duluth: Canada	22	443	--	--
El Paso:				
Canada	--	--	(1)	1
Mexico	11	432	14	605
Total	11	432	14	606
Great Falls: Canada	4	138	6	234
Honolulu: Japan	28	637	6	136
Houston:				
Canada	(1)	4	--	--
United Kingdom	72	1,195	(1)	1
Total	72	1,199	(1)	1
Laredo: Mexico	1	16	1	57
Los Angeles:				
Germany, West	(1)	9	(1)	10
Spain	(1)	16	1	42
Total	(1)	25	1	52
Miami:				
Bahamas	56	1,564	46	1,271
Belgium-Luxembourg	1	30	4	205
Germany, West	30	447	--	--
Mexico	22	292	36	874
Norway	110	2,061	50	827
Spain	119	1,721	112	1,470
Sweden	59	1,029	--	--
United Kingdom	46	675	--	--
Total	443	7,819	248	4,647
Milwaukee: Canada	52	771	31	766
New Orleans:				
Canada	--	--	(1)	(1)
Bahamas	--	--	2	53
Germany, West	--	--	(1)	17
United Kingdom	96	1,710	90	1,588
Total	96	1,710	92	1,658
New York City:				
France	(1)	1	--	--
Norway	255	4,066	215	3,583
Spain	11	198	--	--
Total	266	4,265	215	3,583
Norfolk:				
Bahamas	91	2,075	103	2,339
Canada	--	--	(1)	3
France	312	6,220	178	5,264

See footnotes at end of table.

Table 20.—U.S imports for consumption of hydraulic and clinker cement, by customs district and country —Continued

(Thousand short tons and thousand dollars)

Customs district and country	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Norfolk: —Continued				
Spain	49	767	16	187
United Kingdom	(1)	48	--	--
Total	452	9,110	297	7,793
Ogdensburg: Canada	111	2,244	108	2,618
Pembina:				
Canada	93	2,293	102	2,621
Mexico	--	--	(1)	2
Total	93	2,293	102	2,623
Philadelphia:				
Germany, West	(1)	23	(1)	18
Yugoslavia	2	129	2	170
Total	2	152	2	188
Portland, Maine: Canada	44	901	41	1,256
St. Albans:				
Canada	101	2,280	181	3,820
Italy	--	--	(1)	1
Japan	--	--	(1)	(1)
Norway	--	--	(1)	(1)
United Kingdom	(1)	1	--	--
Total	101	2,281	181	3,821
San Diego: Mexico	--	--	(1)	1
San Francisco: Belgium-Luxembourg	(1)	1	--	--
San Juan:				
Belgium-Luxembourg	13	691	10	532
Colombia	2	64	--	--
Denmark	15	413	--	--
France	(1)	16	(1)	15
Honduras	2	62	--	--
Spain	32	746	23	751
Total	64	1,992	33	1,298
Savannah:				
Denmark	--	--	(1)	1
Mexico	11	137	--	--
Spain	11	180	4	43
United Kingdom	--	--	(1)	1
Total	22	317	4	45
Seattle: Canada	273	3,621	229	4,192
Tampa:				
Bahamas	202	5,590	91	2,532
Belgium-Luxembourg	--	--	(1)	13
Honduras	2	42	--	--
Mexico	103	1,658	124	2,139
Spain	61	831	158	3,137
Sweden	40	719	20	361
Total	408	8,840	393	8,182
Grand total	3,702	70,620	3,107	67,085

[1]Less than 1/2 unit.

WORLD REVIEW

A number of countries announced long-term cement-industry expansion programs that were to provide future self-sufficiency in cement. These included Algeria, Hungary, Poland, Tunisia, the Dominican Republic, and Yugoslavia. In addition, many oil-rich countries pushed ahead with plans to increase cement production to supply their extensive construction programs. Congestion at ports continued to be a problem, particularly in Iran and Saudi Arabia.

In the Middle East, the chemical-admixture market for cement is growing 35% to 40% per year, according to the British Chemical Development Corp. Lack of potable water and local raw materials with high salt content has caused special problems that are being combated by technology involving a variety of admixtures.

The technology in new plant installations clearly shows the continuing concern for energy efficiency in cement manufacture, with the dominance of dry-process, preheater plants.

World cement production increased to 811.5 million tons, 4.8% more than the 1975 total of 774 million tons. The largest increase in production was in Asia, where overall production averaged 10% above that of 1975. Production changes ranged from a 71% increase in Bangladesh to net reductions in some Middle East countries and Nepal.

Oceania showed an increase of 8% over 1975, solely as a result of Australia's 12% boost.

Western European production was virtually the same as in 1975, whereas Eastern European countries expanded output by 3%, to 206 million tons.

Production in North America increased 6% to 105 million tons, and South American countries increased by 1%, manufacturing 38 million tons of cement.

African countries increased production 3% with 26.6 million tons, compared with 25.7 in 1975.

The 10 leading cement-producing countries, according to Bureau of Mines data, were the U.S.S.R., Japan, the United States, Italy, the People's Republic of China, West Germany, France, Spain, Poland, and India.

NORTH AMERICA

Canada.—Construction expenditures in Canada were up about 12% over those in 1975; however, wages and costs of materials increased at approximately equivalent rates, showing that there was no real growth in the cement industry.[11]

Canada's cement exports to the United States dropped for the third successive year, this time by 6%. The 1975 level was down 14% from that of 1974, which was in turn 10% less than 1973 exports.

Canadian cement-producing capacity reported at yearend 1976 was about 16.5 million tons per year, according to the Canadian Department of Energy, Mines, and Resources. Capacity changes during the year resulted in a net reduction of 84,700 tons.

Cement production in all Canadian Provinces for 1976 totaled 10,858,000 tons, 94% of which was produced in six Provinces, as follows: Ontario, 38%; Quebec, 27%; Alberta, 11%; British Columbia, 9%; Manitoba, 6%; and Saskatchewan, 3%.

Genstar's Ocean Cement Ltd. began construction of a new plant at Vancouver, British Columbia, designed to produce 1.2 million tons per year. The $64 million facility was intended to replace an old plant on Vancouver Island by 1978. Genstar also began planning a two-stage expansion of its Edmonton, Alberta, plant. Inland Cement Industries Ltd. began a $60 million program to increase capacity 75% at its Edmonton plant by the early 1980's. The initial stage will be a $3 million electrostatic precipitator system.

St. Lawrence Cement Co., after almost 2 years of government review, took over Ciment Independant of Montreal for $Can67 million (US$68 million) and 200,000 shares of St. Lawrence stock. St. Marys Cement Ltd. installed a new dry-process, four-stage suspension preheater kiln, increasing capacity 661,000 tons per year at its St. Marys, Ontario, plant. Other expansion plans included doubling the capacity of Canada Cement Lafarge Ltd.'s plant at Brookfield, Nova Scotia.

The cement industry in Canada has set a voluntary goal to reduce energy consumption 9% to 12%, compared with that of 1974, by 1980. In 1976, the Canadian cement industry consumed approximately 62 trillion Btu, or about 4% of the energy used by Canadian industry as a whole.

Costa Rica.—Costa Rica produced 399,000 tons of cement in 1976. Cementos del Pacífico S. A. awarded a $30 million contract to Allis-Chalmers Corp. to build a new plant in Guanacaste, about 108 miles from San José. Total estimated cost for the plant will be $55 million.

Dominican Republic.—The Dominican Republic's expectation of becoming a cement exporter in 1976 did not materialize. Surplus production was, however, expected in 1977. Four cement plants were expected to produce about 42 million bags per year. This, compared to the 1976 domestic consumption of 18 million bags, should provide an exportable surplus.

Cementos Nationales S. A. began operation of a new dry-process plant. Fuller Co. was responsible for the turnkey operation. A capacity of 562,000 tons per year was achieved with a single, four-stage suspension preheater kiln. This plant doubled the

[11]Stonehouse, D. H. Cement preprint chapter. Canadian Minerals Yearbook 1976. Department of Energy, Mines and Resources, Ottawa, Canada, 17 pp.

previous national output and provides cement self-sufficiency for the present.[12] The country's previous cement production came exclusively from Fabrica Dominicana de Cemento. Production in 1976 was 585,000 tons.

El Salvador.—A 1,102-ton-per-day suspension preheater kiln and related plant equipment were contracted to be installed by Allis-Chalmers Corp. for Cemento de El Salvador S. A. Completion is scheduled for 1978. Production totaled 366,000 tons in 1976.

Jamaica.—Construction of a 660,000-short-ton-per-year cement plant was scheduled to begin in late 1976. Located on the western end of Jamaica, the plant is expected to cost $J60 million. (US$66 million). The Jamaican Government will own 85% interest, and the Cavendas Group of Venezuela will hold the remaining 15%. Caribbean Cement Co. increased its price of cement in January by 32 cents (US 35 cents) to $J2.28 (US$2.51) per bag. The purpose of the price increase was to generate reserves for the proposed $J25 million (US$27.5 million) expansion program. Prior to the suspension of the program in midyear, $8 million had already been spent. The intended expansion would double potential output to 800,000 tons per year by 1978. National production was 400,892 long tons for 1976.

Mexico.—Cemento Portland Nacional was building a cement plant at Hermosillo, Sonora. Scheduled for completion in 1977, the plant will have a production capacity of 1,500 tons per day. Construction of another 1,500-ton-per-day plant was being planned at Campeche, on the Yucatán Peninsula. Canteras y Calizas de Campeche signed a contract with Capital Plant International and Fives Lille Cail of the United Kingdom. The plant and associated marine loading facilities were expected to cost about £35 million (US$63 million). The plant is scheduled for completion in early 1979.

Cementos Apasco brought a new plant on stream, increasing capacity to 1.5 million tons per year. It is located about 50 miles north of Mexico City, near the village of Apaxco.[13]

An investigation by the U. S. International Trade Commission concluded that antidumping regulations had not been violated by Mexican cement producers.[14]

Total production of cement in Mexico in 1976 was 13,871,000 tons.

SOUTH AMERICA

Barbados and Guyana.—Technical feasibility studies for a joint project of the Governments of Barbados and Guyana were undertaken by Holderbank Consulting Ltd. of Ontario, Canada. The plant, to be constructed in Barbados, would produce 250,000 tons per year of clinker, 100,000 tons of which would be shipped for final processing to Guyana. The project was scheduled for completion in 1979.

Bolivia.—Sociedad Boliviana de Cemento, S. A., at La Paz announced that it would expand its capacity 551 tons per day by 1978. The turnkey project, to be carried out by F. L. Smidth & Co., comprises a four-stage preheater kiln, planetary clinker cooler, a new raw mill with air separator, an open-circuit finish mill, and new storage facilities.

Although Bolivia experienced a mild recession beginning in late 1975 and continuing through the first half of 1976, a construction boom produced higher cement sales. Because of production problems, domestic cement output declined, requiring the importation of 55,000 tons.

Cement production for Bolivia in 1976 was around 243,000 tons from three plants.

Brazil.—Cement production for 1976 was 18.6 million tons, a decrease of 3% compared with that of 1975.

Companhia Nacional Cimento Portland, a subsidiary of Lone Star Industries, Inc., in Rio de Janeiro, began engineering and feasibility studies for a new cement plant to be built at Cantagalo, about 250 miles from Rio de Janeiro. Construction is to begin in 1978. The new plant, which will have a capacity of between 661,000 and 772,000 tons, will eventually replace the present 496,000-ton plant at Guaxindiba. Sociedad de Empreendimentos Industriais Comerciais e Mineração was setting up a 1-million-ton-per-year cement plant at Vespasiano, Minas Gerais, at a cost of $100 million. Cement production grew nearly 20% during the year to one-third of the national total of cement production.

Cimento Tupi S.A. (Blue Circle Group) began production at its new plant at Pedra do Sino in February 1976. Under con-

[12]Rock Products. Dominican Republic Puts New Cement Plant Into Production. V. 79, No. 8, August 1976, pp. 43-47.

[13]MacDonald, D. The New Plant of Cementos Apasco. Rock Products, v. 79, No. 4, April 1976, pp. 86-90.

[14]Federal Register. V. 41, No. 105, May 28, 1976.

——. V. 41, No. 181, Sept. 16, 1976.

U. S. International Trade Commission. Portland Hydraulic Cement from Mexico. USITC Publication 795, December 1976.

struction since 1973, this 661,000-ton-per-year, dry-process plant was reported to be producing near capacity.[15]

Cimento Santa Rita S.A. at São Paulo reportedly completed a new dry-process, 2,200-ton-per-day plant, supplied largely by Allis-Chalmers Corp. cement and mining systems. Itabira Agro-Industrial S. A. installed a 1,000-ton-per-day, two-kiln plant at Cappao Bonito, equipped by the Czechoslovakian Pragoinvest.[16]

Ecuador.—A new cement plant was being planned, to be located near Latacunga in Cotopaxi Province. Cementos Cotopaxi, C. A., was to provide 30% of the financing, with the remainder to be supplied by a foreign partner. The existing Guapan cement plant in Cañar Province was to be expanded from 200-ton-per-day capacity to 1,000-ton-per-day capacity at a cost of $30 million. Production in Ecuador totaled 679,000 short tons in 1976.

Peru.—Cementos Norte Pacasmayo of Lima planned to triple capacity of its Pacasmayo plant. Fuller Co. was to supply the plant with a complete equipment package for a flash calciner-preheater, dry-process kiln plant, at a cost of $7 million. The plant, scheduled for operation by September 1977, was to have a capacity of 3,000 tons per day.[17] Cementos Lima S. A. contracted with Holderbank Consulting Ltd. of Canada for engineering work on a 3,000-ton-per-day expansion of the Atacongo plant near Lima. The existing plant was completed in 1969 and the new facilities were expected to be operational by 1978. Plans call for a flash precalciner, which, when installed, will be the first such unit in Latin America. Cost of the expansion is $100 million.

Peruvian cement production totaled 2,167,000 tons in 1976.

Uruguay.—Administracion National de Combustibles Alcohol y Portland is expanding its plant in Paysandú from 441 to 992 tons per day with a new four-stage preheater system from Fuller Co.'s South American subsidiary.[18]

Venezuela.—Cementos Caribe C. A. of Caracas contracted with Holderbank Consulting Ltd. of Ontario, Canada, to engineer and manage the construction of a new 3,000-ton-per-day, dry-process plant at Puerto Cumarebo. Additional marine distribution facilities will be built as well. Construction was scheduled to begin in 1977, with completion in 1978.[19]

Venezuelan cement production in 1976 was 3.9 million tons.

EUROPE

According to Cembureau, the European Cement Association, cement production in the nine Eastern European countries (Albania, Bulgaria, Czechoslovakia, East German, Hungary, Poland, Romania, the U.S.S.R., and Yugoslavia) in 1975 was 207 million tons, or 27% of the world total. It was estimated that output would increase by 5% per year from 1976 to 1980.

Orders for new cement mills increased during the year, according to the German firm Polysius, A. G. (Neu Beckum, West Germany), and its six overseas affiliates. Much of the increased demand was for turnkey operations for new plants in developing countries.

Albania.—Production in Albania in 1976 was 882,000 tons, a 23% increase compared with that of 1975. Albania has announced its intention to increase production 55% above the 1975 level by 1980. Two plants were known to be operating in 1976, at Fushë-Frujë and Elbasan.

Germany, East.—East Germany produced 12.5 million tons, a 6.5% increase over 1975 production. Eleven plants were distributed around the country, the largest being the Karsdorf Cement Works near Halle, with a capacity of 4.7 million tons per year. Work was being undertaken to expand the capacity of the plant at Duena, near Erfurt, to 2.8 million tons per year. Plans through 1980 are to increase production 25% through better utilization and expansion of existing facilities.

Hungary.—In Hungary, production was 4.7 million tons in 1976 from six plants. The new works at Hejöcsaba went into production officially in April. This gas-fired, dry-process, 1.8-million-ton-per-year plant went into trial operation in January 1975, and produced 248,000 tons that year. Total cost was $230 million. Another new plant at Belapatfalva was scheduled for 1978. It too will be a two-kiln, dry-process plant. Principal fuels will be oil and gas, and capacity is to be 1.25 million tons. Cost was estimated at $220 million.

Ireland.—Ireland's cement and clinker production in 1976 was estimated at 1.5 million tons. Work was progressing on a

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[15]Industrial Minerals. No. 111, December 1976, p. 64.

[16]The Associated Portland Cement Manufacturers Ltd. 1976 Reports and Accounts. 1976, p. 10.

[17]Grancher, R. A. International Cement Review. Rock Products, v. 80, No. 4, April 1977, p. 100.

[18]Rock Products. Rock Newscope. V. 79, No. 7, July 1976, p. 18.

[19]Work cited in footnote 18.

1-million-ton expansion of the Platin plant of Cement Ltd. The project, begun in 1974 at an estimated cost of £40 million, was expected to go onstream in October 1977. The expanded facility will provide Cement Ltd. with a clinker capacity of 2.1 million tons.[20]

Norway.—Production of cement and clinker in Norway in 1976 was about 3.0 million tons. Cement sales were down from those of 1975, largely because of reduced deliveries to North Sea activities. To compensate for higher production costs, the Government permitted an increase in the price of cement by an average of NKr26 per ton (US$4.76 per ton).

Romania.—Romania reported production of 14 million tons of cement in 1976, a 9% increase compared with that of 1975. Construction continued on the new Tasca works, begun in 1975. This two-kiln, dry-process plant was scheduled to begin partial production in 1977, and to be fully operational in 1978.

Spain.—Asland S.A. began production from a new, 1-million-ton-per-year plant at Sagunto, near Valencia. This expands Asland's total capacity from its four plants to 5.5 million tons. As of mid-1976, cement consumption was running at about the same level as in 1975, or at an annual figure of about 28 million tons.

Sweden.—As in other parts of the world, energy efficiency considerations in Sweden have resulted in the building of larger plants and wet- to-dry-process conversion. Euroc estimated that by 1980, four cement plants will produce the same amount as seven plants in 1976. Cementa announced the quadrupling of its Slite plant on the Island of Gotland, at a cost of SKr600 million (US$138 million). Since 1976, Cementa has been the only cement manufacturer in Sweden. Swedish consumption declined to 3 million tons, a 10% decline compared with that of 1975. Exports were 110,000 tons, or 25% of the 1975 level.

U.S.S.R.—The Soviet Union has announced the intention of a maximum growth in cement production of 4% per year through 1980. Production by 1980 was expected to be 177 million tons. Production in 1976 was reported as 137 million tons from 115 plants. Ninety of these plants were operated by the U.S.S.R. Ministry of Construction Materials.

United Kingdom.—Demand for cement in the United Kingdom declined 9% during 1976, the third consecutive year of decreasing cement consumption according to Associated Portland Cement Manufacturers Ltd. (APCM), (Blue Circle Group). Domestic shipments dropped 7.4% to 17 million tons, and production of portland cement fell 7.4% during the year. The 1974 shipments were down 12% from 1973 levels, and those of 1975 declined another 4% from 1974. As a result of this depressed construction market, about 2.2 million tons of capacity was lost because of closures. Exports increased only 2.5% to nearly 1.1 million tons, despite increased exports of cement to the Middle East, Nigeria, and Venezuela.

APCM closed down three older plants during the year. This reduced the country's annual production capability 717,000 tons. Despite the closures, Blue Circle was operating at 80% of capacity. In a step toward energy-cost savings, Blue Circle converted two previously oil-fired plants to burn coal. In addition, the Blue Circle Group installed a full-scale refuse preparation plant. The company has been investigating the use of domestic refuse as a replacement fuel in its kilns. Blue Circle hopes eventually to use 66,000 to 88,000 tons of refuse. An advantage in cement manufacturing, the company reports, is that combustion gases from the refuse neutralize some of the alkalies from the kiln. The new plant was scheduled to go onstream in early 1977.

Tunnel Holdings, Ltd. closed its plant at West Thurrock, Essex. This reduced the company's capacity by nearly 1 million tons, or approximately one-third of its total output. During 1976, a new wet-process kiln of 330,000 tons capacity was installed at Clitheroe, near Manchester.

According to Cembureau, a total of 19 kilns were shut down in 1976, with a combined capacity of 2.3 million tons. The outlook for 1977 was for a further 5% to 6% decline in the construction market, but continued export increases were expected to maintain production at the 1976 level.

The Department of the Environment's Building Research Establishment ordered that buildings throughout the country be inspected for potential hazards caused by the use of high-alumina cement in precast concrete structural members. The problem was caused by a conversion and subsequent weakening of the crystalline structure of the cement upon exposure to heat and moisture.

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[20]The Northern Miner. V. 61, No. 4, Jan. 15, 1976, p. 15.

The price of cement in the United Kingdom increased 6% on November 4, 1976. Further increases were expected to follow in 1977 as a result of continuing increases in the costs of raw materials and labor.

Yugoslavia.—The Partizan Cement Works on the Adriatic Coast requested that Polysius, A.G., deliver a new PREPOL process precalciner kiln, along with quarry machinery, crushers, crushing mill, packaging and loading machinery, and process-automation and electrical equipment. The plant is expected to expand present capacity to 3,500 tons per day. Production for 1976 was 8.4 million tons.

AFRICA

Algeria.—Annual cement capacity for Algeria was rated at about 3.8 million tons. Production for 1976, however, was estimated at less than half of capacity, perhaps 1.5 million tons. Consumption was between 3.5 million and 4 million tons, with the balance being imported. With the 1-million-ton-per-year Al-Asnam plant coming onstream, it was estimated that production will increase at least 25%. Algeria would like to achieve self-sufficiency in construction materials, including the production of cement, by 1980. An average annual growth rate of 13% in cement demand is forecast through 1981. According to World Bank figures for November 1975, Algeria's expansion plans call for increasing national cement production capacity to 8 million tons per year in 1978, with an approximate balance of supply and demand expected by 1979 or 1980. An integral part of this expansion plan is the construction of a 500,000-ton-per-year, dry-process cement plant near Saida, and expansion of distribution facilities nationwide. The Société National des Materiaux de Construction, which dominates the cement market in Algeria, will operate for the Saida plant and all new distribution facilities and equipment. Kawasaki Heavy Industries of Japan will build the turnkey plant.

Kenya.—A new kiln was placed in operation at Bamburi Portland Cement Co. Production was expected to reach 1 million tons per year during 1976.

Libya.—A 3,000-ton-per-day, dry-process cement plant was to be built about 6 miles from the coastal city of Homs. Société Fives-Cail Babcock contracted to supply the turnkey facility at a cost of F700 million (US$146 million). The new system includes a two-stage facility for raw grinding and drying, which uses a 270-ton-per-hour roller mill and is capable of removing moisture up to 12%. The kiln is 17.7 feet in diameter by 290 feet long and uses a four-stage cyclone preheater and a grate-type clinker cooler. Clinker is ground by two closed-circuit ball mills each rated at 100 tons per hour.

Cement produced by Libya in 1976 amounted to 1,653,000 tons valued at £60.3 million.

Morocco.—State-owned Cimenterie de l'Oriental was moving ahead with plans to build a 1.2-million-ton-per-year cement plant near Oujda at a cost of $182 million. Funding was to come from several sources, including the Moroccan Government ($105.5 million), the World Bank ($45 million), the Arab Fund for Economic and Social Development ($24.5 million), and Moroccan commercial banks ($7 million). The project is expected to be completed in 1978. A shortage of cement in Morocco resulted in 740,000 tons being imported in 1976. When in full production, the new plant is expected to save Morocco about $34 million per year in foreign exchange. APCM, which will do the engineering work, will also provide supervisory services for a 1-million-ton-per-year plant at Mediouna, south of Casablanca. Contracts for this plant should be awarded in 1978, with completion scheduled for 4 years from that time.

The new Marrakech cement plant, located 28 miles west of Marrakech, was scheduled to begin production in June 1976. Société des Ciments de Marrakech (Marrakech Cement) was created in December 1972 to finance and develop a project to build the new 550,000-ton-per-year plant. Investors in the $40 million project included the International Finance Corp. and two affiliates of Ciments Lafarge. Planning and construction were supervised by Ciments Lafarge. The new dry-process kiln uses fuel oil.

Ciments Lafarge operated two other cement plants in Morocco—Lafarge Maroc in Casablanca and Société des Ciments Artificiels de Meknes in Meknes. These two plants provided 70% of the country's total cement output.

Nigeria.—Construction began on a new 882,000-ton-per-year cement plant by Ashaka Cement Co. Ltd. Installation of a third kiln was being considered, which would increase annual production capacity to 1.3 million tons. APCM has a 30% interest in Ashaka, which is principally owned by the Nigerian Government.

Nigeria's 1975 cement crisis, in which some 170 cement-laden ships unable to unload lay at anchor at the port of Lagos-Apapay, by mid-1976 resulted in legal actions taken by the United States, the United Kingdom, and West Germany. The suits involve Nigeria's failure to pay heavy demurrage and freight charges incurred when massive congestion developed at the port. The U.S. and German cases involved letters of credit issued by the Bank of Nigeria and its agents; the British suit was directed at the Banco Internacional de Commercio in Madrid, Spain. Out-of-court settlements were reportedly reached by some suppliers, but other cases may yet be brought to court.

The Nigerian National Supply Co. made arrangements to import 3.3 million tons of cement in 1977.

South Africa, Republic of.—Cement production for 1976 was 7.9 million tons, virtually the same as that of 1975. Domestic sales were 1.2% above the 1975 level, and exports dropped in volume by 12.5%. Imports of cement totaled 82,000 tons, a 5% increase compared with those of 1975.

Installed cement production capacity in the Republic of South Africa for 1976 was about 7 million tons per year. An industry goal is to reach 10 million tons capacity by 1980. The Cement Producers Association has indicated that this production is expected to be from new plants with capacities of about 600,000 tons per year each. Single units of less capacity were considered uneconomic in the Republic of South Africa, owing to current construction and operation costs.

Anglo Alpha Cement Ltd. closed its old (1937) plant at Henneman, Orange Free State, owing to high operational costs. To offset that production loss of 100,000 tons per year, Anglo Alpha was scheduling the opening of its new Dudfield plant in 1977. Production capacity of the new plant is expected to be 2.2 million tons per year.

ASIA

Afghanistan.—Three U.S. firms were awarded a contract to build a new cement plant in Afghanistan in the Kandahar region. Oman Construction, Fuller Co., and Fischback & Moore International, Inc. expect to complete the installation in 1979. Capacity will be 1,600 tons per day. The turnkey operation was financed for $50.5 million by the Government of Iran. It was the largest industrial project ever undertaken in Afghanistan.[21]

Bangladesh.—The new Chittagong clinker grinding plant was expected to provide most of the increased cement manufacturing capacity to double the country's production. The new facility supplements the existing Chhatak cement plant. It was expected that the increased production would satisfy 60% of Bangladesh's annual demand of 606,000 tons. Production at the two plants in 1976 was 241,000 tons.

A new 1-million-ton-per-year plant was planned, to be called the Jaipurhat Limestone Mining and Cement Works. This project was estimated to cost around $200 million, and is expected to give the country self-sufficiency in cement or the basis of indigenous resources.

China, People's Republic of.—The number of relatively small vertical-shaft kilns has been increasing very rapidly in China during the last several years. Small cement plants, which are usually located in rural areas and numbered about 200 in 1965, were estimated at 2,800 in 1973. While the overall cement-producing capability of the country has increased, individual plant capacity decreased from an average in 1965 of about 25,500 tons per year to around 7,100 tons per year in 1973. The small vertical-shaft kiln plants can be located in areas with limited transportation and communications facilities, or where raw materials supplies or market demand would preclude establishment of a larger plant. Savings in transportation appears to be a major factor offsetting the economics of scale that would be realized by larger plants in many other parts of the world.

Hong Kong.—National cement production for the year was estimated at around 683,000 tons. Fifty-nine percent of Hong Kong's cement was produced in small plants. Small plant production increased about 7% over that of 1975. Although first quarter cement production was up about 12% in 1976, no yearend national figures were made available by the New China News Agency.

India.—A new cement plant was under construction at Ariyalur, in the Tridhirapalli District for the Government-owned Tamil Nadu Cements Corp. Ltd. of Madras. Research and development programs, under the sponsorship of the Cement Research Institute of India, included studies on the feasibility of cement miniplants for northeastern India (a region that presently has only two cement plants), and an appraisal of vertical-shaft technology.

[21]Work cited in footnote 15.

The amount of cement produced in India in 1976 was 20,392,000 tons.

Indonesia.—In 1976, domestic production of cement was 2 million tons. Extensive expansion of cement-manufacturing capacity was in progress. Plans call for seven cement plant projects, which will increase capacity 6 million tons or more by 1979.

The Indonesian Directorate General of Chemical Industries recommended the construction of 12 new cement plants, each with a capacity of 500,000 tons per year, to meet an estimated market demand of 12 million tons by 1984. Since 1973, cement supply has fallen behind market demand in Malaysia, a principal export market.

Kaiser Cement & Gypsum Corp. was working on an expansion to approximately double the capacity of its Cibinong (Indonesia) plant. Expected completion date was late 1977.

Iran.—Iran plans to increase cement production capability from 6.1 million tons per year in 1976 to 10 million tons in 1977, 16 million tons in 1978, 19 million tons in 1979, and 20 million tons by 1980. All expansion would be by means of large-capacity, dry-process kilns. One plant, the Aria Cement Co., southwest of Isfahan, will use about 1 million tons of slag per year from a nearby steelworks.

Iraq.—Eight new kilns were planned to go into operation in 1977 and 1978, which would increase the 1976 capacity of 3.2 million tons to 7 million tons. Six of the eight new kilns were to use the wet-process. Only two new dry-process kilns were planned—one in 1977 and one in 1978 at the Badoosh plant, Mosul. Each would have a capacity of 0.6 million tons. A 500,000-ton-per-year grinding plant at Umm Qasr was to operate on clinker from the Samawa plant, 186 miles south of Baghdad; a white cement plant with 100,000-tons-per-year capacity was scheduled to be built by 1978.

Israel.—A projected 0.6- to 1-million-ton-per-year capacity plant was planned for the southeastern part of Israel. Currently, three cement plants of the Nesher Co. provide production capacity of approximately 2 million tons per year.

Japan.—In 1976, Japan was the second largest producer of cement in the world. Total cement production in Japan was 75.7 million tons, a 5% increase over 1975.

Kaiser Cement & Gypsum Corp. completed the sale of its 46% equity interest in Ryukyu Cement Co. Ltd. of Okinawa to Ube Industries Ltd. for nearly $7 million.

Japan continued to make significant contributions to cement and concrete research and technology in such areas as alkali-resistant glass fiber for use in concrete reinforcement and the use of steel slag in both cement manufacture and as concrete aggregate.

Japanese exports of cement and clinker were reported up for the year to nearly 6.2 million tons, more than 75% of which went to Southeast Asia, particularly Singapore, Indonesia, Hong Kong, and Malaysia.[22]

Jordan.—Jordan's cement production was 649,000 tons in 1976. A shortage of cement developed during the year as a result of a production breakdown at the Jordan Cement Co. and increased demand owing to a construction boom. Cement can be legally imported into Jordan only by Jordan Cement Co., which is 49.5% Government-owned.

By 1978, one cement plant southwest of Amman will have a capacity of 600,000 tons per year owing to the addition of a 2,000-ton-per-day dry kiln.

Kuwait.—The Kuwait Cement Co. located at Shuwaykh, near Kuwait City, was considering some expansion. In 1976, it was operating a clinker-grinding plant with a capacity of 300,000 tons per year.

Lebanon.—Cimenterie de Sibline planned a new cement plant with a capacity of around 300,000 tons per year. Capacity for 1976 was 2.1 million tons. An increase of 100,000 tons in white cement production was scheduled for 1977.

Malaysia.—Malaysian cement production was expected to increase to about 4 million tons per year by 1980, as a result of planned expansions of the two existing plants and the construction of three new plants by 1979.[23]

Cement production of 1.9 million tons in 1976 was 20% higher than that of 1975.

Oman.—A 350,000-ton-per-year plant was being built at Qurum. It was scheduled for operation in 1978 or 1979.

Pakistan.—The State Cement Corp. of Pakistan owns all of the cement production facilities in the country. Expansion announced for 1976 was expected to increase capacity 2.3 million tons, from 3.5 million tons per year in 1975 to 5.8 million

[22]Harbin, P. The Industrial Minerals of Japan. Industrial Minerals, No. 119, August 1977, pp. 15-39.
[23]Industrial Minerals. No. 110, November 1976, p. 42.

tons. The program included expanding 3 existing works and the erection of 3 new works, bringing the total number of cement plants to 12.

Philippines.—The Philippines exported 779,000 tons of cement during 1976, 12% less than the 884,000 tons exported in 1975. The decline was largely due to decreased sales to Middle East countries, which have been building their own plants to supply extensive on-going building programs.

Domestic production for 1976 was given as 102,607,000 bags (4.8 million tons).

Qatar.—The Qatar National Cement Co. planned to expand its plant at Umm-Bab from 200,000 tons to 300,000 tons per year. Future plans call for further expansion to 900,000 tons per year.

Saudi Arabia.—The 1976 cement-producing capacity of 1.3 million tons per year was expected to increase to 2.2 million tons per year in 1977, 3.1 million tons in 1978, and to 6.9 million tons by the end of the decade. All new capacity will be from dry-process kilns.

El-Kasseim Cement Co. contracted with the KHD Industrieanlagen unit of Humboldt Deutz for a turnkey cement factory valued at 235 million West German marks (US$93 million). It was to be located at Buraydah, 248 miles northwest of Riyadh. Operation was scheduled for 1980, with an annual capacity of 717,000 tons. A Swedish firm, Cementa, was awarded the contract to build a bulk cement terminal at the port of Yanbu. The terminal is to be capable of unloading and packing 700,000 tons per year. Scheduled for completion in 1978, it is intended to help relieve congestion at the port of Jidda. A new company, Saudi Bulkhandling Ltd., consisting of two Saudi Arabian partners and A/S Norcem of Oslo, Norway, planned to import bulk cement by means of two floating silos in the Arabian Gulf.

Syria.—Total Syrian cement capacity in 1976 was 1.7 million tons. This was expected to increase to 2.3 million tons in 1977 and to 4.2 million tons in 1979.

Taiwan.—Cement production in Taiwan totaled 9,644,000 tons in 1976, a 29% increase over the 1975 production figure of 7,491,000 tons. This increase was largely due to the completion during the year of several expansion projects. Domestic demand was expected to have been around 8.5 million tons, leaving an exportable surplus of over 1 million tons. Actual exports reached nearly 600,000 tons, going principally to Hong Kong, Singapore, and Saudi Arabia.

There were 14 plants operating in Taiwan in 1976. The largest producer was Taiwan Cement Corp., which operated four plants with a combined capacity of 4.2 million tons per year.

Thailand.—Several developments improved of the Thai cement industry in 1976. The single most important factor was the investment by the Government of $300 million to improve rural conditions. Other positive factors included the lifting of cement export restrictions, a major construction program announcement by the National Housing Authority, and the Government's raising of price ceilings on domestic sales. Five cement companies had a combined production capacity of 5.6 million tons per year. Production in 1976 was 4.5 million tons, of which 4.3 million tons was domestically consumed and 666,000 tons was exported.

Turkey.—Construction of a new 600,000-ton-per-year cement plant was scheduled to begin at Darende, Malatya, in east central Turkey. The cost of 500 million Turkish lira (US$31 million) was being raised by a new joint stock corporation. Equipment was to be supplied by local manufacturers. The Adana cement plant, Turkey's largest, was to be expanded to a capacity of 1.5 million tons per year by yearend 1977.

United Arab Emirates.—Dubai began work on a 0.5-million-ton-per-year cement plant scheduled to come onstream in early 1978. Abu Dhabi was completing construction of a 250,000-ton-per-year plant, which was to start production in 1976. In Ras al Khaimah, a 250,000-ton-per-year plant was scheduled for completion in 1978, doubling the 1976 capacity of existing works. Sharjah was building a 200,000-ton-per-year-capacity plant to come onstream by 1977.

Vietnam.—A contract for a cement plant valued at 19.57 billion Japanese yen (US$66 million) was awarded to a Japanese-Danish consortium, consisting of the Mitsui Group and F. L. Smidth & Co., by the Vietnamese Techno-Import Agency. The plant is to be located between Hanoi and Haiphong. This was the first major plant contract in Vietnam since unification in April 1976.

Yemen Arab Republic.—According to Cembureau, a cement plant was erected at Bajil, near Hodeida, with a capacity of approximately 200,000 tons per year.

OCEANIA

Australia.—Blue Circle Southern Cement Ltd. announced that it would proceed with the installation of a new, 827,000-ton-per-year, dry-process kiln to replace older units at Berrima, New South Wales. Completion was estimated for late 1978. The project was expected to cost 70 million Australian dollars (US$86 million), and included a 4,500-horsepower cement-grinding mill at Maldon and expanded quarrying and crushing facilities at Marulan. The cement market in New South Wales of about 1.9 million tons per year was being partially supplied by cement from other States. There was virtually no growth in the market in 1975, but it had been increasing at an annual rate of 5% to 6% in previous years. Financing was jointly underwritten by APCM and Broken Hill Portland Ltd.

Blue Circle Southern Cement Ltd. operated four plants in New South Wales and one in Victoria. Total cement production in 1976 was 6.2 million tons.

Table 21.—Hydraulic cement: World production, by country

(Thousand short tons)

Country	1974	1975	1976[p]
North America:			
Bahamas	875	510	299
Canada	11,436	10,763	10,858
Costa Rica	328	364	399
Cuba	[r]2,000	2,296	[e]2,200
Dominican Republic	667	637	585
El Salvador	[r]321	355	366
Guatemala	[r]341	429	491
Haiti	157	165	270
Honduras	237	328	245
Jamaica	[r]446	449	402
Mexico	11,679	12,800	13,871
Nicaragua	260	195	230
Panama	435	397	343
Trinidad and Tobago	267	281	267
United States (including Puerto Rico)	82,888	69,721	74,495
South America:			
Argentina	5,944	6,023	6,296
Bolivia	223	250	243
Brazil	[r]16,440	19,221	18,582
Chile	[r]1,571	1,118	1,062
Colombia	3,840	3,477	3,993
Ecuador	[r]639	654	679
Paraguay	114	152	238
Peru	[r]2,097	2,097	2,167
Surinam	50	34	55
Uruguay	603	702	745
Venezuela	3,851	3,855	3,900
Europe:			
Albania	612	[e]717	[e]882
Austria	7,093	6,206	6,779
Belgium	8,232	7,588	8,272
Bulgaria	[r]4,737	4,804	4,808
Czechoslovakia	9,884	10,251	10,529
Denmark	2,747	2,466	2,596
Finland	2,428	2,274	2,011
France	[r]35,649	32,615	32,401
Germany, East	[r]11,132	11,743	12,506
Germany, West	39,658	36,945	37,649
Greece	[r]7,738	8,565	9,628
Hungary	3,789	4,144	4,738
Iceland	171	181	160
Ireland	[r]1,693	1,720	[e]1,516
Italy	40,024	37,738	40,039
Luxembourg	409	431	378
Netherlands	4,506	4,085	3,837
Norway	2,907	2,994	2,948
Poland	18,480	20,393	21,826
Portugal	[r]3,733	3,800	3,854
Romania	12,340	12,699	13,831
Spain (including Canary Islands)	[r]24,514	26,422	27,780
Sweden	3,648	3,440	3,084
Switzerland	[r]5,790	4,150	3,909
U.S.S.R	[r]126,925	134,482	136,651
United Kingdom	19,603	18,625	16,865
Yugoslavia	7,327	7,788	8,396
Africa:			
Algeria	1,037	1,053	1,543
Angola	838	717	[e]772

See footnotes at end of table.

Table 21.—Hydraulic cement: World production, by country —Continued

(Thousand short tons)

Country	1974	1975	1976[p]
Africa —Continued			
Cameroon	[r]234	277	[e]276
Cape Verde Islands	4	[e]4	[e]4
Egypt	3,598	3,955	3,631
Ethiopia	127	112	[e]121
Ghana	[r]574	758	[e]772
Ivory Coast	[r]693	794	[e]882
Kenya	944	989	1,064
Liberia	[r]96	99	[e]99
Libya	[r]535	915	1,653
Malagasy Republic	67	64	82
Malawi	[r]98	127	90
Mali	46	54	[e]55
Morocco	[e]2,110	2,235	2,324
Mozambique	513	353	[e]331
Niger	23	19	40
Nigeria	[r]1,329	1,524	[e]1,543
Rhodesia, Southern	831	746	596
Senegal	366	398	419
South Africa, Republic of	8,048	7,910	7,937
Sudan	331	154	143
Tanzania	326	293	266
Togo	[r]142	198	184
Tunisia	[e]593	679	527
Uganda	169	108	97
Zaire	[r]685	692	[e]694
Zambia	[r]489	498	[e]424
Asia:			
Afghanistan[1]	[r]166	162	[e]184
Bangladesh	96	141	241
Burma	186	200	252
China, People's Republic of[e]	27,560	33,100	38,600
Cyprus	373	675	1,131
Hong Kong	629	633	[e]683
India	[e]15,745	17,895	20,392
Indonesia	916	1,187	[e]1,988
Iran	4,986	5,919	[e]6,063
Iraq	[r]2,001	[e]2,976	2,629
Israel	1,980	2,413	2,204
Japan	80,588	72,220	75,742
Jordan	657	631	649
Khmer Republic[e]	55	55	55
Korea, North[e]	6,600	6,600	6,600
Korea, Republic of	9,747	11,165	13,088
Kuwait	252	314	[e]320
Lebanon	1,922	1,818	[e]1,874
Malaysia	1,504	1,594	1,917
Mongolia	188	175	[e]176
Nepal	44	50	33
Pakistan	[r]3,825	3,379	3,413
Philippines	3,861	4,700	4,823
Qatar	[e]134	181	190
Saudi Arabia	[r]1,164	[e]1,543	[e]1,322
Singapore	1,157	1,240	[e]1,488
Sri Lanka	522	433	462
Syria	1,064	1,096	1,224
Taiwan	6,802	7,491	9,644
Thailand	4,324	4,364	4,526
Turkey	[e]9,846	11,966	13,609
Vietnam[e]	771	772	772
Yemen	66	66	[e]66
Oceania:			
Australia	5,738	5,530	6,176
Fiji Islands	93	79	76
New Caledonia	73	66	[e]66
New Zealand	1,224	1,184	1,101
Total	[r]775,183	774,277	811,502

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Year beginning March 21 of that stated.

TECHNOLOGY

Cement Manufacture.—Research and development efforts focused largely on means of improving energy efficiency in the manufacture of cement and efficient uses of cement in concrete products and structures.

Municipal refuse, mixed with coal, was first used to fire a cement kiln at the APCM plant in Westbury, Wiltshire County, England.[24] The system developed by APCM first pulverizes, then screens the refuse. When blown into the kiln at high velocity, it is completely oxidized. It was anticipated that by adding approximately 6% refuse to coal by weight, a 3% to 4% savings in coal would result. Four to 5 tons of pulverized refuse is calculated to have the same energy content as 1 ton of coal. In addition to the energy recovery potential of the process, alkaline flue emissions normally associated with cement manufacture are to some extent neutralized by acid gases produced by the refuse incineration. The process, reportedly, does not affect product quality.

Humboldt-Wedag Co. of West Germany completed an investigation into a new clinker-grinding system designed to be more energy-efficient than the closed-circuit, two-compartment tube mill. According to Humboldt-Wedag, very fine particles that are returned from the classifier interfere with grinding performance. The new proposed grinding system feeds the product of each compartment of the tube mill into a coarse classifier assigned to that compartment. Each classifier delivers coarse material, free of fines, back to the individual compartments of the mill and routes the fines from each classifier to the next coarse classifier. A final stage of coarse and fine classifiers supplies the finished product.

Dyckerhoff Zementwerke, A.G., of Wiesbaden, West Germany, conducted a study to determine "clinkerability" of cement raw meal. Experiments were conducted controlling temperatures or burning times. "Clinkerability," it was determined, depends on fineness of grind, homogeniety, and lime and silica content, and is influenced by the time-temperature relationship of the burning process.[25]

Dyckerhoff Zementwerke also installed a computer-operated continuous sampling device and control system. Supplied by Polysius, A.G., the system analyzes fluctuations in the raw mix with a computer-calibrated X-ray fluorescence apparatus. The system provided improved homogeniety of the raw-meal composition and allowed more uniform kiln operation.[26]

A precalcining system using pelletized feed, developed by Steven Gottlieb of Australia, had been licensed to Heyl & Patterson of Pittsburgh, Pa., for design, sale, and installation in the Western Hemisphere. The system uses hot kiln gas and supplemental heaters in a precalciner to increase productivity of existing kilns. Alkalies are removed in a high-velocity gas flow and collected by an electrostatic precipitator.[27] No installation had been made or planned in North America.

A new British standard, BS4982, *Standard sizes of refractory bricks for use in rotary cement kilns, Part 2, Fireclay and high alumina refractories,* prescribes sizes of refractory bricks for use in rotary kilns that produce cement clinker. The Cement Makers Federation and British refractory brick producers participated in its preparation. The standard was intended to reduce the number of shapes of refractory brick being produced. Nomograms appended to the standard give the approximate number of bricks needed for different kiln diameters.

Blended Cements.—The use of blended cements containing fly ash and slag received increased attention as part of the push toward energy conservation and as a means of waste product utilization. A program sponsored by the Federal Energy Administration to examine the feasibility of intergrinding fly ash, slag, and kiln dust, was undertaken by the Southwest Research Institute and General Portland Inc.[28] This was reported on at the Fourth International Ash Utilization symposium in March. It was projected that 2 million tons per year of coal and 14,000 tons of raw materials could be saved by 10% fly ash substitution in any Type I cement. A major obstacle to the use

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[24]Ironman, R. Refuse Used As Fuel Source. Rock Products, v. 79, No. 6, June 1976, pp. 83-84.
Industrial Minerals. No. 105, June 1976, p. 12.

[25]Ironman, R. International Report. Rock Products, v. 79, No. 10, October 1976, p. 26.

[26]Work cited in footnote 25.

[27]Rock Products. Rock Newscope. V. 79, No. 10, October 1976, p. 17.
Heyl & Patterson, private communication.

[28]Stearn, E. W. Blended Cements Make Gains—But Slowly. Rock Products, v. 79, No. 10, October 1977, pp. 60-61.

of blended cements was lack of applicable tests and standards.

Researchers at the National Bureau of Standards, under sponsorship of the Energy Research and Development Administration (ERDA), worked toward the development of standards for Type IP and Type IS cements. Bureau of Standards scientists reported that fly ash cement might be an acceptable substitute for any type specified by the American Society for Testing Materials (ASTM) except Type III (high early strength), if restrictive ASTM specifications were modified to conform with new research findings relating to performance of the blended cements.

Opinion was divided among cement producers regarding the economies of fly ash cement. According to Rock Products magazine, 18 States permitted use of Type IP cement for some uses. Several firms used ash as a replacement for shale.

At the National Ash Association, 4th International Ash Utilization Symposium, St. Louis, Mo., March 24-25, 1976, Leon Trief, a Belgian chemist, described a fly ash cement that he had developed. The product, which incorporates 70% fly ash, reportedly requires one-third the capital investment for its manufacture compared with conventional cement. Further, it is claimed that only one-half as much energy is required and that iron and unburned carbon can be profitably recovered. In the process, blended raw materials (fly ash and limestone) are heated to 1,430° C. The resulting slag is quenched by pressurized water to form a granular material which is, in turn, wet ground to a diameter of less than 10 micrometers with a specific surface of greater than 10,000 square centimeters per gram. The product, according to the developer, cures more fully and faster than conventional cement, develops high overall mechanical strength, has high resistance to chemical attack, and low heat of hydration. A pilot plant was being planned to produce 165,000 tons per year at Liège, Belgium.[29]

Direct utilization of ash in concrete production also increased during the year.

Slag cements were produced in the Netherlands, Belgium, and Iran. Nihon Cement Co. in Japan studied plans for new cement and slag aggregate facilities.

The PCA, in continued testing of Type IP cements, determined that, in comparison to Type I, they exhibited similar freeze-thaw resistance and strength development and showed somewhat less drying shrinkage, but were slightly less resistant to deicer scaling.[30]

New Cements.—A quick-setting specialty cement was developed containing powdered wollastonite and buffered phosphoric acid. It sets in less than 30 minutes, is water insoluble, and develops a compressive strength of over 7,500 pounds per square inch within 4 hours. Potential applications include highway patching, cement pipe, sprayable foam insulation, flame-resistant coatings, etc.[31]

A high-strength cement was developed and put to use in the construction of Chicago's Water Tower Place. The 76-story structure incorporated cement capable of strengths up to 8,000 to 10,000 pounds per square inch. Additional new technology was required to proportion cement and lightweight aggregates for use in the upper 25 stories of the building.[32]

A plant to produce cement from the ash of burned rice husks was set up in a village in India. Aau, in the Banda District, has the first facility which makes what is reported as an architecturally attractive and structurally sound cement from this waste product. An advantage to rice husk cement, in addition to low cost, is acid resistance reportedly superior to that of portland cement. The average Indian rice crop supplies enough husk to provide about 2.5 million tons of the cement per year.

Concrete.—Research in improved concrete products included the use of steel fibers to increase shock resistance for pavement resurfacing; and thick, unreinforced concrete in highways. In addition, concrete railroad ties and concrete long-span bridges were tested; more than a dozen such bridges were on the drawing boards as a result of testing of a structural model by the PCA.

A manufacturing-plant package for producing a new fiberglass-reinforced concrete sheet was being offered to manufacturers in the United Kingdom. The package included machinery, installation, training, and start-

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[29]Chemical and Engineering News. New Cement Uses Fly Ash, Costs Less To Make. V. 54, No. 14, Apr. 5, 1976, p. 16.

[30]Perenchio, W. F., and P. Klieger. Further Laboratory Studies of Portland-Pozzolan Cements. Portland Cement Association Research and Development Bulletin RD041.01T, 1976.

[31]American Ceramic Society Bulletin. V. 55, No. 11, November 1976, pp. 983-985, 988.

[32]The Medusa Mirror (Medusa Cement Co.). Medusa Corp., Cleveland, Ohio, winter 1975-76, pp. 1-4.

up. The reinforced concrete sheets are made from a cement slurry and alkali-resistant fiber that are sprayed onto a moving conveyor. The panels can be curved into three-dimensional shapes, grooved, or provided with openings. The panels can be used for earth-retaining segments, gutters, roofing, walls for swimming pools, and fire-resistant building construction. The alkali-resistant glass fiber was to be marketed in the United Kingdom. The product was to be used in the manufacture of a new fiberglass-reinforced concrete pipe.[33] The United Kingdom has also reported development of a new concrete pump for small users. ACS Engineering developed a unit capable of pumping concrete with 3/4-inch aggregate up to 60 feet vertically and 100 feet horizontally or 250 feet horizontally only.[34]

A joint company, Dytam, formed by Tampimex Oil, a British subsidiary of Ingram Corp. of New Orleans, La., and Dyckerhoff & Widman of Munich, West Germany, announced the design of a concrete ship to carry liquid natural gas (LNG) from Middle Eastern countries and Indonesia to North America, Europe, and Japan. LNG is viewed by some as a major energy resource for the 1980's. Between 60 and 100 new LNG carriers may be needed during the coming decade. The concrete design reportedly has been shown by extensive computer studies to be superior to steel-hulled counterparts in fatigue strength, corrosion resistance, maintenance costs, and ability to withstand the very low temperature of the gas (-160° C), as well as the impact of collision or explosion. Furthermore, the cost of construction should be 15% less than for a steel-hulled ship of the same capacity. The entire hull would be a monolithic construction of prestressed concrete, reinforced longitudinally transversely. Its length is envisioned at 950 feet, with a capacity of 4,507,520 cubic feet of LNG.[35]

A marketing agreement was signed between Giba-Geigy (United Kingdom) and Kao Soap of Japan to market a concrete additive in Europe, Africa, and the Middle East. The additive is to be used in production of flowing and high-strength concretes, fluid mortar, and grouting.[36]

The British Department of Energy announced a 2-year research program testing the use of reinforced and prestressed concrete as a structural material for offshore platforms, particularly in the hostile North Sea environment. Fatigue strength of large prestressed concrete towers under stress by varying sea and wind loads is one of the areas being investigated. Other areas include materials research relating to corrosion and temperature effects on concrete structures exposed to seawater, and investigations of failure modes of concrete platforms.[37]

A new British standard, BS5328, Methods of Specifying Concrete, was issued by the British Standards Institute. The standard distinguishes between performance and prescription specifications.[38]

An increase in the use of manufactured sand (stone sand) in portland cement concrete was reported.[39]

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[33]Financial Times (London). Oct. 4, 1976.
[34]Financial Times (London). June 15, 1976.
[35]Financial Times (London). Apr. 10, 1976.
[36]Financial Times (London). Feb. 23, 1976.
[37]London Times. Feb. 27, 1976.
[38]Financial Times (London). Dec. 4, 1976.
[39]Aikin, H. B. Stone Sand For Concrete. Pit & Quarry, v. 69, No. 6, December 1976, pp. 109-111, 114.

Chromium

By John L. Morning[1]

The year was marked by the first domestic production of chromite since 1961, although the output was small. Demand for chromium alloys increased substantially over that of 1975 but failed to reach the level of 1973-74. Chromite ore prices held their gains of 1975, while those of chromium alloys decreased as increased imports and stocks put pressure on prices. The Republic of South Africa's ferrochromium production capacity continued to grow as a new plant came onstream late in the year, and additional capacity was announced as being under construction. The South African Minerals Bureau estimated that the country's chromite reserves, to a depth of 300 feet, totaled 3.4 billion short tons.

Table 1.—Salient chromite statistics

(Thousand short tons)

	1972	1973	1974	1975	1976
United States:					
Exports	20	21	18	139	124
Reexports	57	34	99	45	85
Imports for consumption	1,056	931	1,102	1,252	1,275
Consumption	1,140	1,387	1,450	881	1,006
Stocks, Dec. 31: Consumer	857	597	573	952	1,009
World: Production	6,725	7,381	r8,244	r9,071	9,492

rRevised.

Legislation and Government Programs.—Government chromium material inventories are shown in table 2. Included in the inventories as material sold but unshipped were chemical-grade chromite, 98,000 tons; refractory-grade chromite, 305,000 tons; and metallurgical-grade chromite, 580,000 tons. Deliveries of chromite from prior-year sales of stockpile excesses included the following: Chemical-grade chromite, 22,048 tons; refractory-grade chromite, 180,215 tons; and metallurgical-grade chromite, 109,408 tons.

During the year, no chromium material was available for sale from government stockpile excesses. Congressional authorization was required for disposal of materials.

New stockpile goals for chromium materials, established in October by the Federal Preparedness Agency of the General Services Administration, are shown in table 2. These goals were based on a material stockpile capable of supporting U.S. defense requirements for a major war over a 3-year period.

At yearend 1975, the U.S. Department of the Treasury made a final countervailing determination in the case of ferrochromium from the Republic of South Africa and held that no bounties or grants were being paid on the production or exportation of ferrochromium. However, in January a domestic concern gave notice that it desired to contest the determination before the U.S. Customs Court. No action was taken in 1976.

The U.S. Environmental Protection Agency (EPA) issued the first national standards for Federal air pollution control, covering new and modified ferroalloy

[1]Physical scientist, Division of Ferrous Metals.

production plants. Emission of particulate matter is limited to less than 0.51 pound per megawatt-hour for furnaces producing chromium alloys.

Producers of ferroalloys at a special Trade Policy Staff Committee (Office of Special Representative for Trade Negotiations) hearing urged the restoration of duties on seven ferroalloys classified for the General Systems of Preferences (GSP). Under the GSP, ferrochromium imports from Brazil, Yugoslavia, Taiwan, and Turkey entered duty-free. The GSP went into effect January 1, 1976, and is reviewed annually. No change was made in 1976.

A preliminary report on the demand and supply of nonfuel minerals and materials, including chromium, for the U.S. energy industry, in 1975-90 was published by the U.S. Geological Survey.[2] Policy implications of producer-country supply restrictions on the world chromite market were the subject of a report prepared for the National Bureau of Standards.[3] The report discussed various aspects of chromium, including supply and demand of chromite, supply disruptions, potential adjustments in chromite use, welfare losses and optional policies, and past crises in the chromite market.

Under a contract from the Office of Mineral Policy Development, U.S. Department of the Interior, an econometric model of the world chromite industry was prepared.[4] The specific structure of the model assessed supply and demand on a worldwide basis as well as stocks and prices. According to the report, the basic model can be used to forecast market behavior from 1975 on.

Table 2.—U.S. Government chromium stockpile material inventories and goals

(Thousand short tons)

	Goal	Inventory by program, Dec. 31, 1976			
		National stockpile	Defense Production Act	Supplemental stockpile	Total[1]
Chromite, chemical-grade	734	348	--	--	348
Chromite, metallurgical-grade	2,550	2,164	580	323	3,067
Chromite, refractory-grade	642	601	--	103	705
Ferrochromium, high-carbon	236	126	--	276	403
Ferrochromium, low-carbon	124	128	--	191	319
Ferrochromium-silicon	69	26	--	33	58
Chromium metal	10	--	--	4	4

[1]Data may not add to totals shown because of independent rounding.

DOMESTIC PRODUCTION

Domestic mine production of chromite ceased in 1961 when the last Government Defense Production Act contract was phased out. Production on a small scale was restarted in 1976 when Marmac Resources Co. rehabilitated the Butler Estates mine and mill near Coalinga, Calif. Most of the usable output was exported because of high transportation costs to domestic markets.

Although domestic chromite production was small, the United States continued to be a substantial chromite consumer in producing chromium alloys, refractories, and chemicals. The principal producers of these products follow:

[2]Albers, J. P., W. J. Bawiec, and L. F. Rooney. Demand for Nonfuel Minerals and Materials by the United States Energy Industry, 1975-90. U.S. Geol. Survey Prof. Paper 1006-A, 1976, 19 pp.

Goudarzi, G. H., L. F. Rooney and G. L. Shaffer. Supply of Nonfuel Minerals and Materials for the United States Energy Industry, 1975-90. U.S. Geol. Survey Prof. Paper 1006-B, 1976, 37 pp.

[3]National Bureau of Standards. Policy Implications of Producer Country Supply Restrictions (Prepared for the Experimental Technology Incentives Program). Contract #4-35960, August 1976, 233 pp.

[4]Charles River Associates Inc. (CRA). Econometric Model of the World Chromite Industry (Prepared for Office of Minerals Policy Development, U.S. Department of the Interior). CRA Rept. 250, November 1976, 190 pp.

Company	Plant
Metallurgical industry:	
Airco Alloys, Air Reduction Co., Inc	Calvert City, Ky.
	Niagara Falls, N.Y.
	Charleston, S.C.
Chromium Mining & Smelting Corp	Woodstock, Tenn.
Foote Mineral Co	Keokuk, Iowa.
	Graham, W.Va.
Interlake, Inc	Beverly, Ohio.
Prairie Metals and Chemicals, Inc	Prairie, Miss.
Satralloy Corp	Steubenville, Ohio.
Shieldalloy Corp., Division of Metallurg, Inc	Newfield, N.J.
Union Carbide Corp	Niagara Falls, N.Y.
	Marietta, Ohio.
	Alloy, W.Va.
Refractory industry:	
Basic, Inc	Maple Grove, Ohio.
Corhart Refractories Co., Inc	Pascagoula, Miss.
Davis Refractories, Inc	Jackson, Ohio.
General Refractories Co	Baltimore, Md.
	Lehi, Utah.
Harbison-Walker Refractories (a division of Dresser Industries, Inc.)	Hammond, Ind.
	Baltimore, Md.
Kaiser Aluminum & Chemical Corp	Moss Landing, Calif.
	Columbiana, Ohio.
	Plymouth Meeting, Pa.
North American Refractories, Co. Ltd	Womelsdorf, Pa.
Ohio Fire Brick Co	Jackson, Ohio.
Chemical industry:	
Allied Chemical Corp	Baltimore, Md.
Diamond Shamrock Corp	Castle Haynes, N.C.
PPG Industries, Inc	Corpus Christi, Tex.

Airco Alloys, a division of Air Reduction Co., Inc., announced a shifting of its emphasis on production of ferroalloys in the United States and Sweden. Additional ferrosilicon capacity came onstream at Niagara Falls, N.Y., during the year, and a 40,000-kilowatt ferrochromium furnace at Charleston, S.C., was upgraded to 60,000 kilowatts. In Sweden, the firm was converting two furnaces from ferromanganese to ferrochromium production. Although ferromanganese output was not reduced in the United States, more emphasis was to be placed on silicon and chromium alloys.

Interlake, Inc., announced that it was entering the blocking-chromium and high-soluble-chromium markets. Two grades of each type of alloy were offered for sale.

Union Carbide Corp. announced that between 60% and 70% of the output of the new Tubatse ferrochromium plant in the Republic of South Africa would be marketed in the United States. When shipments start arriving in 1977, the firm plans to convert one of its two chromium-producing furnaces to ferromanganese production.

Foote Mineral Co. discontinued production of special proprietary chromium alloys because of environmental considerations. Foote planned to stock most of its H.S. Chrome 50 and V-5 Foundry Alloy throughout 1976.

Consolidated Rail Corp. (Conrail) reduced ferroalloy freight rates in November. This reportedly was done to meet competition from highway carriers and enable domestic producers to compete with imported alloys. The rate change amounted to an average reduction of $6 per ton for many source-destination combinations. The new rates applied to chromium, manganese, molybdenum, nickel, and silicon.

Table 3.—Production, shipments, and stocks of chromium ferroalloys and chromium metal

(Short tons)

Alloy	Production: Gross weight	Production: Chromium content	Shipments	Producer stocks, Dec. 31
1975:				
Low-carbon ferrochromium	53,958	37,875	46,988	14,208
High-carbon ferrochromium	117,831	78,071	118,268	47,295
Ferrochromium-silicon	52,508	19,467	41,590	12,354
Other[1]	24,296	14,380	22,426	4,999
Total	248,593	149,793	229,272	78,856
1976:				
Low-carbon ferrochromium	29,386	19,686	33,091	11,394
High-carbon ferrochromium	162,577	105,237	164,088	63,294
Ferrochromium-silicon	55,328	19,776	51,867	16,785
Other[1]	19,839	12,909	20,218	4,643
Total	267,130	157,608	269,264	96,116

[1]Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

CONSUMPTION AND USES

Domestic consumption of 1,006,000 tons of chromite ore and concentrate containing about 289,000 tons of chromium was 14% above that of 1975. Of the total chromite consumed, the metallurgical industry used 59.3%; the refractory industry, 20.1%; and the chemical industry, 20.6%. The metallurgical industry consumed 596,850 tons of chromite containing 177,000 tons of chromium in producing 267,130 tons of chromium alloys and metal. About 52.0% of the metallurgical-grade ore had a chromium-to-iron ratio of 3:1 and over, 17.6% had a ratio between 2:1 and 3:1, and 30.4% had a ratio of less than 2:1.

Chromium has a wide range of applications in the three primary consuming industries. In the metallurgical industry, its principal use was in stainless steel. Of the total chromium alloys consumed, stainless steel accounted for 70%, full-alloy steels for 16%, high-strength low-alloy and electrical steels for 4%, and carbon steels for 1%. Total chromium alloy consumption increased 24% above that of 1975.

The refractory industry utilized chromium in the form of chromite primarily for manufacturing of refractory bricks to line metallurgical furnaces. Consumption of chromite for refractory purposes increased 10% compared with that of 1975.

The chemical industry consumed chromite for manufacturing sodium and potassium bichromate, which are base materials for a wide range of chromium chemicals. Chromite consumption in this industry increased 25% compared with that of 1975.

Table 4.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States

Year	Metallurgical industry: Gross weight (thousand short tons)	Metallurgical industry: Average Cr_2O_3 (percent)	Refractory industry: Gross weight (thousand short tons)	Refractory industry: Average Cr_2O_3 (percent)	Chemical industry: Gross weight (thousand short tons)	Chemical industry: Average Cr_2O_3 (percent)	Total: Gross weight (thousand short tons)	Total: Average Cr_2O_3 (percent)
1972	727	47.9	224	35.9	189	45.7	1,140	45.2
1973	920	48.1	261	35.0	206	45.3	1,387	45.2
1974	904	47.0	295	35.2	251	44.8	1,450	44.2
1975	532	44.6	183	34.5	166	44.9	881	42.5
1976	597	43.4	202	35.0	207	44.8	1,006	42.0

Table 5.—U.S. consumption and consumer stocks of chromium ferroalloys and metal in 1976

(Short tons, gross weight)

	Low-carbon ferro-chromium	High-carbon ferro-chromium	Ferro-chromium silicon	Other	Total
Steel:					
Carbon	1,164	3,089	1,251	187	5,691
Stainless and heat resisting	49,942	176,906	61,577	2,395	290,820
Full alloy	14,974	44,180	4,078	4,341	67,573
High-strength low-alloy and electric	1,945	8,267	2,013	3,048	15,273
Tool	1,015	3,749	125	18	4,907
Cast irons	1,049	9,142	201	496	10,888
Superalloys	3,425	4,885	297	1,840	10,447
Alloys (excluding steels and superalloys):					
Welding and alloy hard-facing rods and materials	848	1,084	W	365	2,297
Other alloys[1]	1,475	1,266	--	1,999	4,740
Miscellaneous and unspecified	3,057	769	75	61	3,962
Total	78,894	253,337	69,617	[2]14,750	416,598
Chromium content	54,065	159,480	25,507	9,207	248,259
Stocks, Dec. 31, 1976	10,100	52,553	3,995	[3]3,300	69,948

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."
[1]Includes magnetic and nonferrous alloys.
[2]Includes 3,790 tons of chromium metal.
[3]Includes 839 tons of chromium metal.

STOCKS

Although demand for chromium in 1976 was substantially stronger than in 1975, a high level of chromite and ferrochromium imports increased industry stocks. Total industrial chromite stocks increased 6%. Stocks in the metallurgical and chemical industries increased 9% and 14%, respectively, while stocks in the refractory industry decreased 12%, compared with those of 1975. Consumer chromium alloy stocks increased 3%, and producer stocks increased 22%. Combined consumer and producer chromi¨m alloy stocks totaled nearly 175,000 tons at yearend, equivalent to about a 4 months' supply at the 1974 consumption rate. A considerable tonnage of chromium alloys was in the hands of traders at yearend.

Stocks of chromium chemicals (sodium bichromate equivalent) at producer plants increased from 15,205 tons in 1975 to 16,257 tons in 1976.

Table 6.—Consumer stocks of chromite, December 31

(Thousand short tons)

Industry	1972	1973	1974	1975	1976
Metallurgical	601	339	340	701	762
Refractory	160	154	169	154	136
Chemical	96	104	64	97	111
Total	857	597	573	952	1,009

Table 7.—Consumer stocks of chromium ferroalloys and chromium metal, December 31

(Short tons, gross weight)

Product	1972	1973	1974	1975	1976
Low-carbon ferrochromium	10,666	15,802	14,937	10,974	10,100
High-carbon ferrochromium	12,061	24,162	25,280	50,076	52,553
Ferrochromium-silicon	3,391	6,740	10,227	4,418	3,995
Other[1]	1,304	1,752	3,303	2,352	3,300
Total	27,422	48,456	53,747	67,820	69,948

[1]Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

PRICES

Published prices of Turkish and Soviet chromite, which more than doubled in 1975, held at the same level throughout 1976. Soviet chromite was quoted at $150 per metric ton, Black Sea ports; Turkish chromite was quoted at $132 to $142 per long ton, Turkish ports. The published price of $37 to $52 per metric ton for South African Transvaal chromite during the second half of 1975 narrowed to $36 to $42 per ton at the beginning of 1976. In August, the price rose to $38 to $46 per metric ton for the balance of the year.

Although demand for chromium alloys increased over that of 1975, the large stock holdings of producers, consumers, and traders lowered prices for chromium alloys. The price of U.S. charge chromium decreased 7 cents per pound of chromium during the year, while the price of imported charge chromium decreased about 11 cents per pound of chromium. The prices of all grades of low-carbon ferrochromium decreased significantly during the year. The price of both types of chromium metal, which began the year at $2.44 per pound, was increased 16 cents per pound in October. Prices of chromium alloys and metal as published in Metals Week follow:

Material	January	December
	Cents per pound of chromium	
U.S. charge chromium	50	43
U.S. high-carbon ferrochromium	54-61	61
Imported charge chromium	44-50	35.5-37
U.S. low-carbon ferrochromium (0.05% carbon)	92-120	85
U.S. low-carbon ferrochromium (0.025% carbon)	97	85
Imported low-carbon ferrochromium (0.05% carbon)	73-83	68-72
Simplex (low-carbon)	92	85
	Cents per pound of product	
Aluminothermic chromium metal	244	263
Electrolytic chromium metal	244	263

FOREIGN TRADE

Exports of chromite decreased 11% and reexports increased 89%, compared with those of 1975. Sweden received 49% of the exports followed by the Netherlands, 28%; Japan, 9%; and Mexico and Canada, 7% each. Three other countries received small quantities. Reexports of chromite totaling nearly 85,000 tons were made primarily to Mexico, 45%; Sweden, 25%; Canada, 17%; and the United Kingdom, 11%. Two other countries received the balance.

Ferrochromium exports totaled 13,563 tons valued at $8.8 million, went to 15 countries, and were about the same as those of 1975. The leading recipients were Canada, 53%; the Netherlands, West Germany, and Italy, 8% each; and Brazil and Sweden, 6% each.

Chromium and chromium alloys (wrought and unwrought) and waste and scrap exports totaled 594 tons valued at $11.9 million. Of the 32 countries receiving shipments, Jamaica accounted for 27%, Canada for 14%, Israel for 11%, and Argentina and France for 7% each.

Exports of pigment-grade chromium chemicals totaled 456 tons valued at $1.1 million. Japan (53%) and Canada (25%) were the principal recipients among the 22 countries receiving shipments. Exports of non-pigment-grade chromium chemicals totaled 3,623 tons, 78% higher than in 1975. Total exports were valued at $5.5 million.

Exports of sodium bichromate were 35% higher than in 1975, totaling 14,280 tons valued at $6.4 million. Canada (40%), the People's Republic of China (12%), Colombia (10%), the Republic of Korea (8%), and Argentina and Japan (7% each) were the leading recipients of the 29 countries receiving shipments.

Imports of chromite increased 2% in quantity and 16% in value compared with 1975 totals. Imports of chromite from Finland and the Republic of South Africa increased significantly, while those from the U.S.S.R., Southern Rhodesia, and the Philippines dropped sharply. Chromite was received from Sweden as a reexport since Sweden does not produce chromite.

Although imports of low-carbon ferrochromium were about the same as in 1975, imports of high-carbon ferrochromium decreased 31%. Imports of the two grades of ferrochromium totaled 243,000 tons valued at $125 million. Japan supplied 45% and the Republic of South Africa 17% of the low-carbon ferrochromium. High-carbon ferrochromium was supplied primarily by the Republic of South Africa (42%), Southern Rhodesia (22%), Brazil (15%), and Yugoslavia (12%).

Ferrochromium-silicon imports increased to 15,725 tons, nearly four times those of 1975, and were valued at $7.6 million. Five countries supplied imports, with Southern Rhodesia accounting for 84% of the total.

Chromium carbide imports from three countries totaled 164 tons valued at $857,000. West Germany supplied 97% of the total.

Imports of chromium metal, wrought and unwrought and waste and scrap, increased to 2,306 tons from 1,629 tons in 1975. Total value increased from $6.6 million to $9.1 million. Of the seven countries supplying imports, the United Kingdom accounted for 59% and Japan for 35%.

Imports of chromium-containing pigments follow: Chrome green, 151 tons; chrome yellow, 2,747 tons; chromium oxide green, 691 tons; molybdenum orange, 333 tons; strontium chromate, 257 tons; and zinc yellow, 1,225 tons. Total value of these products was $10.7 million, 2.5-fold higher than in 1975. Chrome yellow accounted for 51% of total value of these products, followed by zinc yellow with 23%. The leading supplier was Canada, which accounted for 49% of total value.

Sodium chromate and dichromate imports totaled 570 tons valued at $1.1 million. The U.S.S.R. was the sole supplier. Four tons of potassium dichromate valued at $4,600 was imported from Sweden and West Germany.

Table 8.—U.S. exports and reexports of chromite ore and concentrates

(Thousand short tons and thousand dollars)

Year	Exports		Reexports	
	Quantity	Value	Quantity	Value
1974	18	1,430	99	3,101
1975	139	6,896	45	2,111
1976	124	5,609	85	5,475

Table 9.—U.S. imports for consumption of chromite, by grade and country

(Thousand short tons and thousand dollars)

Country	Not more than 40% Cr_2O_3			More than 40% but less than 46% Cr_2O_3			46% or more Cr_2O_3			Total		
	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value
1975:												
Albania	--	--	--	45	20	2,108	6	3	205	51	23	2,313
Finland	19	4	629	--	--	--	--	--	--	19	4	629
India	--	--	--	--	--	--	12	7	855	12	7	855
Iran	--	--	--	--	--	--	11	5	1,376	11	5	1,376
Philippines	202	66	6,611	--	--	--	8	4	220	210	70	6,831
Rhodesia, Southern	12	5	398	23	10	1,077	103	51	5,706	138	66	7,181
South Africa, Republic of	(1)	(1)	1	218	101	4,513	71	33	1,740	289	134	6,254
Turkey	55	21	2,144	31	13	1,369	87	41	7,278	173	75	10,791
U.S.S.R	57	22	3,253	--	--	--	292	153	21,168	349	175	24,421
Total	345	118	13,036	317	144	9,067	590	297	38,548	1,252	559	60,651
1976:												
Albania	--	--	--	18	8	1,858	--	--	--	18	8	1,858
Canada	(1)	(1)	1	--	--	--	(1)	(1)	1	(1)	(1)	2
Colombia	4	1	211	--	--	--	--	--	--	4	1	211
Finland	120	36	4,437	--	--	--	49	35	1,462	169	71	5,899
India	18	7	845	--	--	--	--	--	--	18	7	845
Philippines	163	53	5,614	--	--	--	3	2	169	166	55	5,783
Rhodesia, Southern	12	4	369	9	4	379	14	7	650	35	15	1,398
South Africa, Republic of	26	9	732	318	141	9,737	94	44	3,617	438	194	14,086
Sweden	26	4	68	--	--	--	--	--	--	26	4	68
Turkey	115	44	8,334	31	14	3,161	66	31	7,461	212	89	18,956
U.S.S.R	69	27	4,885	--	--	--	120	62	16,084	189	89	20,969
Total	553	185	25,496	376	167	15,135	346	181	29,444	1,275	533	70,075

[1] Less than 1/2 unit.

Table 10.—U.S. imports for consumption of ferrochromium, by country

Year and country	Low-carbon ferrochromium (less than 3% carbon)			High-carbon ferrochromium (3% or more carbon)		
	Gross weight (short tons)	Chromium content (short tons)	Value (thousands)	Gross weight (short tons)	Chromium content (short tons)	Value (thousands)
1975:						
Brazil	386	214	$479	15,653	8,885	$6,651
Canada	--	--	--	(1)	(1)	1
Finland	--	--	--	6,050	3,092	2,447
France	959	671	1,083	--	--	--
Germany, West	4,415	3,205	5,076	2,084	1,354	1,442
India	969	623	762	661	433	269
Japan	17,782	11,816	23,409	67,188	42,102	51,380
Korea, Republic of	11	6	16	--	--	--
Norway	2,392	1,585	2,458	986	653	661
Rhodesia, Southern	5,238	3,714	5,369	76,855	51,832	33,160
South Africa, Republic of	24,221	14,511	11,002	75,068	41,101	29,219
Sweden	2,853	2,169	4,039	--	--	--
Taiwan	--	--	--	340	213	310
Turkey	1,874	1,297	1,734	441	317	282
Yugoslavia	142	122	162	12,241	8,073	9,219
Total	61,242	39,933	55,589	257,567	158,055	135,041
1976:						
Brazil	937	530	722	26,896	15,459	10,126
Canada	(1)	(1)	1	(1)	(1)	1
France	3,426	2,460	3,335	--	--	--
Germany, West	3,695	2,667	3,899	1,661	1,075	1,081
India	--	--	--	440	284	142
Italy	20	14	20	1,098	707	481
Japan	28,986	19,359	23,582	9,849	6,045	5,098
Mozambique	--	--	--	1,462	816	616
Norway	2,857	1,974	2,414	1,156	787	687
Rhodesia, Southern	8,194	5,785	8,098	39,193	26,561	15,132
South Africa, Republic of	11,022	6,829	8,168	75,706	41,380	26,650
Sweden	3,008	2,218	3,470	--	--	--
Turkey	1,109	777	989	--	--	--
United Kingdom	(1)	(1)	1	--	--	--
Yugoslavia	496	348	85	21,385	14,193	10,021
Total	63,750	42,961	54,784	178,846	107,307	70,035

[1]Less than 1/2 unit.

Table 11.—U.S. import duties

Tariff classification	Article	Rate of duty Jan. 1, 1976[1]
	CHROMIUM ORES AND METAL PRODUCTS	
601.15	Chromium ore	Free.
607.30	Ferrochromium, less than 3% carbon	4% ad valorem.
607.31	Ferrochromium, over 3% carbon	0.625 cent per pound on chromium content.
632.18	Unwrought chromium other than alloys: Waste and scrap[2]	5% ad valorem.
	CHROMIUM CHEMICAL AND RELATED PRODUCTS	
420.08	Potassium chromate and dichromate	1.1 cents per pound.
420.98	Sodium chromate and dichromate	0.87 cent per pound
422.92	Chromium carbide	6% ad valorem.
	CHROMIUM PIGMENTS	
473.10	Chromium green	5% ad valorem.
473.12	Chromium yellow	Do.
473.14	Chromium oxide green	Do.
473.16	Hydrated chromium oxide green	Do.
473.18	Molybdenum orange	Do.
473.19	Strontium chromate	Do.
473.20	Zinc yellow	Do.

[1]Not applicable to centrally planned economy countries.
[2]Duty temporarily suspended on waste and scrap.

WORLD REVIEW

Brazil.—Chromite reserves were reported at about 40 million tons, of which only 10 million tons are recoverable by existing technology. Most of the chromite is the high-chromium variety with about 14% of the total designated as high-iron chromite.[5]

The sole chromium alloy producer, Cia. Ferro Ligas da Bahia S.A. (Ferbasa), produced the three chromium alloys, high-carbon, low-carbon, and ferrochromium-silicon. Six furnaces were utilized with a combined capacity of 51 megawatts in 1976.

Reportedly, Kloeckner and Co., the world trading arm of the German steel company Kloeckner-Werke A.G., entered into a joint venture with Ferbasa S.A. to mine chromite in Brazil. The new firm was named Ferklock S.A.

Egypt.—According to Egyptian sources, production of chromite was 812 tons in 1972, 485 tons in 1973, and 295 tons in 1974.

Finland.—Outokumpu Oy, Finland's sole chromite producer, increased mining of chromite and sales of ferrochromium despite a weak market. Excavation of ore increased 24% as sales of crude ore were made to Sweden and the United States. The beneficiating plant produced 158,000 tons of concentrate and nearly 35,000 tons of chromite sands for foundry use. Although chromite pellet production was down 9%, production of ferrochromium increased slightly to over 44,000 tons. A new stainless steel works was completed at Tornio, and the first melting and casting of ingots was performed in May, using the firm's own ferrochromium and nickel.

India.—India's chromite production in 1976 was estimated at 442,000 tons, or 20% less than in 1975. Most of the production came from the State of Orissa, with small quantities reported from the States of Karnataka and Marharashtra. Most chromite mining was by open pit methods, and the industry employed about 6,000 workers.

India's chromite reserves were estimated at over 17 million tons but are assumed to be higher on the basis of exploration drilling to depths of 330 feet. Principal mines are currently being worked to depths of about 100 feet. Twenty-four percent of the reserves are proved, 14% are indicated, and the balance are inferred. Nearly 75% of India's reserves are in the State of Orissa.

Ferrochromium production of 11,164 tons in 1975 increased to 15,724 tons in 1976. The State-owned Mysore Minerals Ltd. reportedly was evaluating a proposal by Japanese interests to establish a 7,000-ton-annual-capacity ferrochromium plant in Karnataka. The Japanese proposal envisages relocating a charge chromium plant, including two furnaces, from the Republic of South Africa to India.

Iran.—During Iran's fiscal year of March 1975 to March 1976, reported chromite production totaled 232,000 tons and graded 46% to 48% Cr_2O_3. Proven reserves totaled 1.5 million tons of 40% to 48% chromite, while probable reserves totaled over 2 million tons.

Japan.—The Japanese Ministry of Finance approved budgetary requests to establish two nonferrous metal stockpiling corporations during Japan's 1976 fiscal year. One corporation would specialize in handling chromium, nickel, cobalt, and tungsten. Initial funding, as a direct subsidy from the Japanese Government, would total $173,000. The remaining funds of $33 million would be collected from more than 20 investing firms. The stockpile corporation anticipates beginning with a 2-week supply and eventually increasing this to a 3-month supply of the various metals. Japan's chief concern with respect to these metals is possible shortages owing to availability from only a few sources.

Malagasy Republic.—The Malagasy Government in December 1975 took 100% ownership of Compagnie Minière d' Andriamenta (COMINA), formerly owned by the Péchiney-Ugine Kuhlmann Group (France). Under the takeover settlement, COMINA retained one-third of future output at a predetermined price and contracted to manage and operate the mine.

Production in 1976 was from two mines located near the mining districts of Andriamena and Befandriana. At the larger of the two mines, near Andriamena, the chromite grades at 38% Cr_2O_3 and was concentrated to 50% before being transported by road and rail to Tamatave. The unconcentrated ore at Befandriana grades at 35% to 40% Cr_2O_3 and was trucked to Analalava.

Ore reserves have been estimated at 2.2 million tons at Andriamena and about 280,000 tons at Befandriana. Exploration

[5]See, J. B. Ferroalloys in Brazil. National Institute for Metallurgy, South Africa, Rept. 1777, Jan. 15, 1976. 26 pp.

Table 12.—Chromite: World production, by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
Albania	788	[e]859	[e]875
Argentina	(2)	[e](2)	[e](2)
Brazil	[r]119	191	[e]190
Colombia[e]	13	13	NA
Cuba[e]	22	[r]35	35
Cyprus	37	30	10
Egypt	(2)	[e]1	[e]1
Finland	[r]182	365	456
Greece	11	25	30
India	[r]437	550	442
Iran	193	[e]190	[e]176
Japan	29	26	24
Malagasy Republic	172	214	244
New Caledonia	--	2	11
Pakistan	11	11	12
Philippines	584	573	471
Rhodesia, Southern[e]	650	650	670
South Africa, Republic of	2,069	2,288	2,656
Sudan	22	17	24
Thailand	--	(2)	--
Turkey[e 3]	734	739	816
U.S.S.R.[e]	2,150	2,290	2,337
Vietnam[e]	NA	NA	10
Yugoslavia	1	2	2
Total	[r]8,224	9,071	9,492

[e]Estimate. [p]Preliminary. [r]Revised. NA Not available.
[1]In addition to the countries listed, Bulgaria and North Korea may also produce chromite, but production is not reported and available information is inadequate for formulation of output estimates.
[2]Less than 500 tons.
[3]Salable chromite estimated from run of mine output.

for new deposits was planned by Péchiney-Ugine Kuhlmann and C. Itoh and Co. Ltd. of Japan.

New Caledonia.—Société de la Tiebaghi, a French subsidiary of Inco Ltd., reached agreement with Compagnie Minière Dong-Trieu and two subsidiaries of the Compagnie Financière de Paris et des Pays-Bas group for an exploration program and feasibility study to determine whether a long-closed chromite mine in New Caledonia could be reopened on an economic basis. The mine was purchased by Inco after its closing in 1962. The exploration program and study are expected to take about 2 years and cost about $3 million.

Philippines.—Output of chromite decreased 18% compared with that of 1975; 76% was classified as high aluminum (refractory) chromite and 24% as high-chromium chromite.

In addition to the two traditional chromite producers, Acoje Mining Co. Inc., producing high-chromium chromite, and Consolidated Mines Inc., producing high-aluminum chromite, nine new producers came onstream between 1975 and 1977. Misamis Exploration Corp., Amer-Asia Mining and Development Corp., and Capitol Resources and Development Co., Inc., became high-aluminum chromite producers in 1976, and G. Lluch and Sons, Silverio Eleazar, San Grace Mining Corp., and Velore Mining Corp. became high-chromium chromite producers in 1976. New Frontier Mines and Superior Mines became high-aluminum chromite producers in 1975.

Obit Philippines Consolidated Mines Ltd. produced and sold small tonnages of chromite to Consolidated Mines, which beneficiates and also markets the concentrate. The firm indicated that reserves totaled 2.2 million tons of ore in its claim area, but that no drilling had been performed.

Rhodesia, Southern.—Reportedly, Rhodesian Alloys (Pty) Ltd. at Gwelo may install new furnaces for expansion of charge chromium production. The firm traditionally produces high-carbon ferrochromium, low-carbon ferrochromium, and ferrochromium-silicon.

In March, Mozambique's President declared a state of war against Southern Rhodesia, closed the border, seized all Rhodesian property, and declared that the United Nations sanctions would be applied fully. The action affected the supply of chromite and ferrochromium, which had been shipped through the port of Maputo.

South Africa, Republic of.—Production of ferrochromium in the Republic of South Africa increased 10% during 1976, rising to nearly 263,000 tons. Production was primarily by Ferroalloys Ltd., Southern Cross

Steel (Pty) Ltd., Palmiet Chrome Corp. (Pty) Ltd., and South African Manganese Amcor Ltd. Late in the year, the Tubatse Ferrochrome (Pty) Ltd. facility at Steelpoort, jointly owned by Union Carbide Corp. and General Mining Corp., came onstream.

In late 1975, South African Manganese Amcor Ltd. (SAMANCOR) (formerly South African Manganese Ltd.) acquired all of Amcor Ltd.'s operating subsidiaries. SAMANCOR has a chromite production capability of 200,000 tons annually and planned to increase output to 430,000 tons by 1980. Other plans included increasing ferrochromium production to 165,000 tons annually.

Consolidated Metallurgical Industries Ltd., a member of Johannesburg Consolidated Investment Co. Ltd., was given approval in 1975 to construct a 132,000-ton-per-year ferrochromium plant at Lydenburg. Construction was initiated in 1976. Reportedly, the British Steel Corp. and a Japanese firm will be partners.

South Africa's growing ferroalloy industry, based on proposed new furnace installations, is expected to increase to 1,200 megawatts of transformer capacity in 1981 from about 600 megawatts in 1974, according to a report at a Conference on Energy in Southern Africa.[6] Most of the new capacity is expected to be used for the production of ferrochromium.

In a report by the South African Minerals Bureau, Department of Mines, chromite reserves to a depth of about 1,000 feet were estimated to total 3.4 billion tons, more than double those reported by the U.S. Geological Survey and Bureau of Mines in recent years.

Shipments of chromite for export throughout the year suffered a bottleneck at the port of Maputo, Mozambique. Lack of maintenance and trained manpower reportedly was the cause. Ore carriers often encountered delays of several weeks, resulting in high demurrage costs and unpredictable delivery schedules. At yearend, the chromium and iron ore loading facilities at Maputo were scheduled for maintenance, thereby further restricting shipments of ore. The Republic of South Africa planned contingency steps to make facilities available to back up the shipping facilities at Maputo.

Sudan.—Two Japanese firms, Mitsubishi Corp. and Japan Metals & Chemicals Co., signed a basic agreement for the development of chromite deposits in Sudan. The long-known deposits in the Ingessena Hills region of eastern Sudan have been subjected to exploration drilling in recent years. Reportedly, the project calls for an annual production of 230,000 to 330,000 tons by 1980, if a joint venture is established after a feasibility study.

Sweden.—Avesta Jernwerks A.B. reportedly closed its ferrochromium production operation because it could not meet pollution control restrictions. Avesta had an annual capacity of 25,000 tons of ferrochromium; output was consumed within the company.

U.S.S.R.—The Donskoy mining and concentrating complex at Khrom-Tau in Oktyubinsk Oblast' of Kazakhstan produces over 90% of the Soviet chromite. The Donskoy deposits are selectively mined by open pits. In 1976, 100-ton unit-rig trucks and large bulldozers were used for the first time. During the year, two concentrators were in operation at Khrom-Tau. Crude ore from the Donskoy complex contained 45% chromic oxide, which was upgraded to a 53.9% chromic oxide marketable product.

TECHNOLOGY

A survey of chromium and nickel wastes, and technology presently available to recover these elements, was described by Bureau of Mines researchers.[7] A great variety of industrial wastes containing chromium and nickel values are generated annually which are not recovered. Much of the technology available has been developed in Bureau laboratories. The status of the most promising technology and recommendations for pilot plant or industrial trials were presented.

Thermodynamic properties of chromium fluorides were investigated by the Bureau of Mines as part of a continuing study to provide fundamental data for various phases of metallurgical research.[8] Gibbs

[6]Jochens, P. R. and J. S. Stanko. Fuel Requirements in the Ferroalloy Smelting Industry. Pres. Conf. on Energy and Its Future in Southern Africa, Cape Town, South Africa, Apr. 28-May 1, 1975, 12 pp.

[7]Dressel, W. M., L. C. George, and M. M. Fine. Chromium and Nickel Wastes - A Survey and Appraisal of Recycling Technology. Proc. of the Fifth Mineral Waste Utilization Symposium, Apr. 13-14, 1976, Chicago, Ill., pp. 262-270.

[8]Schaefer, S. C. Free Energies of Formation of Chromous, Chromic, and Chromium (II, III) Fluorides by Electromotive Force Measurements. Bur. Mines Rept. 8172, 1976, 19 pp.

free energies of formation for various chromium fluorides were determined by electromotive force measurements of reversible high-temperature galvanic cells employing calcium fluoride doped with 1 mole-percent yttrium fluoride as the electrolyte.

Bureau of Mines research projects during the year included studies on reclamation of used refractories containing chromium, treatment of metallurgical wastes containing chromium, preparation of low-carbon ferrochromium by carbothermal reduction of chromite, recovery of chromium from domestic chromium-bearing materials, and improved beneficiation of chromium resources.

Tests and plant experience using the COBO (cold bonded) process for chromite in Sweden were described.[9] Production cost, at a capacity of 20 tons per hour, 114 hours per week, was given as $9 (Canadian) per ton. The plant flexibility was reported as very high and easily shiftable from one ore mixture to another. The binder addition was hydrated lime and silica dust recovered from ferrochromium-silicon production. Pellets had a satisfactory strength for transport and were storable for an unlimited time outdoors. Also, compared with costs of other agglomeration methods, the investment and operation costs were low.

The standard free energy of formation of sodium chromate at high temperatures was measured.[10]

A method for recycling spent chromic acid etchant reportedly was developed and put into commercial use by General Motors Corp.[11] The system is based on reoxidation of chromium by electrochemical regeneration of the spent etchant solution. Over 100,000 pounds of chromic acid was expected to be retained and reused in 1976.

Patent activity for chromium during the year concerned removal of chromite impurities from ilmenite;[12] prereduction of the iron content of chromite, magnetic separation of the iron, and reduction of elemental chromium in an electric furnace;[13] refining of ferrochromium to lower sulfur and silicon contents;[14] and production of sodium bichromate.[15]

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[9]Lindberg, N. G., and T. A. Falk. The COBO Process Applied to Chromite Agglomeration. CIM Bull., v. 69, No. 773, September 1976, pp. 117-126.

[10]Liang, W. W., and J. F. Elliott. The Standard Free Energy of Formation of Liquid Na_2CrO_4, 1,100-1,200 degrees K (Kelvin). J. Electrochem. Soc., v. 123, Nov. 5, 1976, pp. 617-620.

[11]American Metal Market. V. 83., No. 183, Sept. 17, 1976, p. 7.

[12]Bergeron, M., and S. F. Prest (assigned to Quebec Iron and Titanium Corp.). Removal of Chromite Impurities From Ilmenite. U.S. Pat. 3,935,094, Jan. 27, 1976.

[13]Fey, M. G. Sequential Recovery of Iron and Chromium From Chromite. U.S. Pat. 3,997,333, Dec. 14, 1976.

[14]Harada, M., S. Kojima, K. Ohta, and H. Shimomura (assigned to Nippon Kokan K. K.). Refining of Carbon-Unsaturated Ferrochromium to Lower the Sulfur and Silicon Content Without Desulfurizing Out of the Furnace. U.S. Pat. 3,953,195, Apr. 27, 1976.

[15]Baiwens, R., R. Lefrancois, and M. Gabiel (assigned to Produits Chimiques Ugine Kuhlmann). Extraction of Chromium Values as Pure Sodium Bichromate From Chromite Ore Leach Solutions. U.S. Pat. 3,933,972, Jan. 20, 1976.

Clays

By Sarkis G. Ampian[1]

Clays in one or more of the classification categories (kaolin, ball clay, fire clay, bentonite, fuller's earth, or common clay and shale) were produced in 47 States and Puerto Rico. Clay production was not reported in Alaska, the District of Columbia, Rhode Island, or Vermont. The States leading in output were Georgia, 7.5 million tons; Ohio, 4.3 million tons; and Texas, 3.7 million tons; followed in order by North Carolina, Wyoming, Alabama, and Pennsylvania. Georgia also led in total value of clay output with $273.1 million; Wyoming was second with $40.0 million. Compared with 1975 figures, clay production increased in 29 States and value increased in 38 States. Total quantity of clays sold or used by domestic producers in 1976 was 7% higher in tonnage, and rose 25% in total value. The total value of clays produced was an alltime high. Increases in value per ton were reported for all clays in 1976 owing to increased labor, fuel, and material costs. The energy crisis or, more specifically, the increasing shortage and costs of fuels continued to cause considerable concern among clay producers and clay product manufacturers. Industrywide efforts were made to both economize and obtain standby fuels for their requirements. The costs of environmental protection equipment and environmental restrictions, and rising capital costs, combined with the energy crisis, continued to adversely affect production during 1976.

Production of the specialty clays; kaolin, ball clay, fire clay, bentonite, and fuller's earth—and common clay and shale, all increased. A small upturn in construction that increased the demand for building materials (brick, lightweight aggregate, vitrified clay pipe, clay floor and wall tile, etc.) was responsible for the rise in production of common clay and shale. Production of kaolin increased 15%, ball clay and fuller's earth 13% each, bentonite 9%, fire clay 3%, and common clay and shale 5%.

Kaolin in 1976 accounted for only 12% of the total clay production but for 53% of the value.

[1]Supervisory physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient clay and clay products statistics in the United States[1]

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
Domestic clays sold or used by producers:					
Quantity	59,456	64,351	60,796	49,047	52,389
Value	$303,022	$354,058	$422,542	$424,556	$528,745
Exports:					
Quantity	1,847	2,097	2,451	2,315	2,487
Value	$66,216	$79,774	$114,212	$120,298	$151,953
Imports for consumption:					
Quantity	67	53	43	38	39
Value	$1,309	$1,879	$2,193	$1,947	$1,814
Clay refractories, shipments: Value	$274,679	$327,265	$410,153	$409,879	$448,471
Clay construction products, shipments: Value	$722,236	$772,723	$694,737	$655,779	$783,644

[1]Excludes Puerto Rico.

Table 2.—Clay sold or used by producers in the United States in 1976, by State[1]

(Short tons)

State	Kaolin	Ball clay	Fire clay	Ben-tonite	Fuller's earth	Common clay and shale	Total	Total value
Alabama	134,408	--	372,971	W	--	1,731,341	[2]2,238,720	[2]$10,325,412
Arizona	--	W	--	27,921	--	W	[3 4]27,921	[3 4]361,386
Arkansas	48,486	--	--	--	--	998,033	1,046,519	3,396,274
California	128,808	370	86,189	87,724	--	1,992,487	2,295,578	13,570,198
Colorado	--	--	29,317	W	--	450,202	[2]479,519	[2]1,976,210
Connecticut	--	--	--	--	--	130,483	130,483	427,080
Delaware	--	--	--	--	--	11,241	11,241	7,900
Florida	24,550	--	--	--	412,832	242,638	680,020	20,671,838
Georgia	4,924,648	--	9,941	--	521,286	2,015,540	7,471,415	273,145,169
Hawaii	--	--	--	--	--	W	W	W
Idaho	W	--	W	W	--	W	W	W
Illinois	--	--	50,883	--	W	1,258,136	[5]1,309,019	[5]3,271,685
Indiana	--	--	2,065	--	--	1,262,642	1,264,707	2,308,429
Iowa	--	--	--	--	--	1,016,772	1,016,772	2,244,873
Kansas	--	--	--	W	--	1,063,831	[2]1,063,831	[2]1,868,714
Kentucky	--	W	85,814	--	--	668,425	[3]754,239	[3]2,394,957
Louisiana	--	--	--	--	--	512,572	512,572	1,158,137
Maine	--	--	--	--	--	133,617	133,617	216,060
Maryland	--	W	--	--	--	702,361	[3]702,361	[3]1,816,949
Massachusetts	--	--	--	--	--	125,934	125,934	237,706
Michigan	--	--	--	--	--	1,934,334	1,934,334	4,741,192
Minnesota	W	--	--	--	--	W	W	W
Mississippi	--	W	--	373,457	W	1,113,723	[3 5]1,487,180	[3 5]8,849,111
Missouri	67,519	--	809,273	--	--	1,256,298	2,133,090	14,914,610
Montana	--	--	1,266	158,695	--	31,660	191,621	2,356,634
Nebraska	--	--	--	--	--	149,275	149,275	344,683
Nevada	W	--	--	7,512	W	W	[4 5 6]7,512	[4 5 6]174,300
New Hampshire	--	--	--	--	--	W	W	W
New Jersey	--	--	11,549	--	--	50,000	61,549	330,712
New Mexico	--	--	W	--	--	55,926	[7]55,926	[7]116,086
New York	--	W	--	--	--	649,543	[3]649,543	[3]2,089,523
North Carolina	W	--	--	--	--	2,750,011	[6]2,750,011	[6]4,677,254
North Dakota	--	--	--	--	--	W	W	W
Ohio	--	--	700,078	--	--	3,587,644	4,287,722	14,703,927
Oklahoma	--	--	--	--	--	1,154,656	1,154,656	1,678,247
Oregon	--	--	--	1,814	--	145,258	147,072	315,431
Pennsylvania	W	--	838,757	--	--	1,452,729	[6]2,291,486	[6]16,036,949
Puerto Rico	--	--	--	--	--	W	W	W
South Carolina	623,222	--	--	--	16,000	1,631,062	2,270,284	17,288,029
South Dakota	--	--	--	W	--	123,842	[2]123,842	[2]137,066
Tennessee	--	513,745	--	W	W	1,015,924	[2 5]1,529,669	[2 5]11,577,910
Texas	W	15,773	54,335	39,414	W	3,596,912	[5 6]3,706,434	[5 6]8,846,656
Utah	W	--	4,590	2,000	2,238	197,340	[6]206,168	[6]530,933
Virginia	--	--	--	--	--	862,036	862,036	1,210,199
Washington	--	--	W	--	--	380,856	[7]380,856	[7]1,140,537
West Virginia	--	--	W	--	--	275,138	[7]275,138	[7]463,583
Wisconsin	--	--	--	--	--	W	W	W
Wyoming	--	--	--	2,495,797	--	201,440	2,697,237	40,015,203
Undistributed	176,119	270,983	295,222	326,047	389,226	647,770	2,105,367	37,220,920
Total	6,127,760	800,871	3,352,250	3,520,381	1,341,582	37,579,632	52,722,476	529,158,672

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1]Includes Puerto Rico.
[2]Excludes bentonite.
[3]Excludes ball clay.
[4]Excludes common clay and shale.
[5]Excludes fuller's earth.
[6]Excludes kaolin.
[7]Excludes fire clay.

Table 3.—Number of mines from which producers sold or used clay in the United States in 1976, by State

State	Kaolin	Ball clay	Fire clay	Bentonite	Fuller's earth	Common clay and shale	Total
Alabama	8	--	9	1	--	28	46
Arizona	--	1	--	3	--	4	8
Arkansas	3	--	--	--	--	16	19
California	8	2	9	13	--	40	72
Colorado	--	--	5	5	--	27	37
Connecticut	--	--	--	--	--	4	4
Delaware	--	--	--	--	--	1	1
Florida	1	--	--	--	3	3	7
Georgia	55	--	2	--	7	17	81
Hawaii	--	--	--	--	--	1	1
Idaho	1	--	1	1	--	4	7
Illinois	--	--	4	--	2	16	22
Indiana	--	--	4	--	--	23	27
Iowa	--	--	--	--	--	15	15
Kansas	--	--	--	1	--	21	22
Kentucky	--	5	8	--	--	9	22
Louisiana	--	--	--	--	--	12	12
Maine	--	--	--	--	--	6	6
Maryland	--	1	--	--	--	9	10
Massachusetts	--	--	--	--	--	3	3
Michigan	--	--	--	--	--	9	9
Minnesota	1	--	--	--	--	3	4
Mississippi	--	2	--	6	4	21	33
Missouri	10	--	75	--	--	19	104
Montana	--	--	1	3	--	8	12
Nebraska	--	--	--	--	--	5	5
Nevada	1	--	--	6	1	1	9
New Hampshire	--	--	--	--	--	2	2
New Jersey	--	--	2	--	--	1	3
New Mexico	--	--	2	--	--	4	6
New York	--	1	--	--	--	13	14
North Carolina	2	--	--	--	--	45	47
North Dakota	--	--	--	--	--	5	5
Ohio	--	--	26	--	--	70	96
Oklahoma	--	--	--	--	--	15	15
Oregon	--	--	--	2	--	15	17
Pennsylvania	1	--	56	--	--	31	88
Puerto Rico	--	--	--	--	--	3	3
South Carolina	17	--	--	--	1	30	48
South Dakota	--	--	--	2	--	4	6
Tennessee	--	27	--	--	1	20	48
Texas	1	--	9	4	1	84	99
Utah	3	--	5	1	1	7	17
Virginia	--	--	--	--	--	13	13
Washington	--	--	1	--	--	14	15
West Virginia	--	--	2	--	--	4	6
Wisconsin	--	--	--	--	--	1	1
Wyoming	--	--	--	43	--	4	47
Total	112	39	221	91	21	710	1,194

DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

Domestic production of kaolin in 1976 increased 15%, and the value increased 31%. The average unit value for all grades of kaolin in 1976 was $46.17 per ton, $5.64 higher than in 1975. Kaolin was produced at mines in 14 States. Two States, Georgia (80%) and South Carolina (10%), accounted for 90% of the total U.S. production in 1976. Alabama ranked third; California, fourth; and Missouri, fifth. Output in 1976 increased in Alabama, Florida, Georgia, Minnesota, North Carolina, and South Carolina, and declined in Arkansas, California, Idaho, Missouri, Nevada, Pennsylvania, Texas, and Utah. No kaolin production was reported in 1976 for Colorado.

Kaolin is defined as a white, claylike material approximating the mineral kaolinite. It has a specific gravity of 2.6 and a fusion point of 1,785°C. The other kaolin-group minerals, such as halloysite and dickite, are encompassed.

In April 1976, Freeport Kaolin Co., a division of Freeport Minerals Co., which mines and processes kaolin in Georgia, completed a 24-mile slurry pipeline from its new Scott mining complex near Sandersville, in Washington County, to its main processing plant in Gordon. The new Scott complex currently produces 250,000 tons per year, with a capability of 500,000 tons. Engelhard Minerals and Chemicals Corp., also in Georgia, was in the process of expanding calciner capacity and backup facilities at McIntyre to produce a high-brightness specialty pigment. Engelhard also increased capacity for a fluid bed catalyst based on calcined clay. Thiele Kaolin Co. was doubling the capacity of its 60,000-ton-per-year airfloat plant at Reedy Creek, near Wrens, Ga. The enlargement was scheduled for completion in the first half of 1977. Georgia Kaolin Co. ordered a second high-gradient magnetic separator (HGMS) for its Sandersville plant (American Industrial Clays). The production capacity of its Dry Branch plant was scheduled for expansion and startup in 1977. A non-Georgia kaolin clay producer, Harris Mining Co., Spruce Pine, N. C., purchased 4,000 acres of land in Avery and Mitchell Counties. The purchase, contiguous to present holdings, was made to insure a constant supply of the company's products—primary kaolin and muscovite.[2]

Exports of kaolin, as reported by the U.S. Department of Commerce, decreased from 880,000 tons valued at $47.9 million in 1975 to 839,000 tons valued at $57.6 million in 1976. The tonnage of kaolin exported in 1976 decreased 5%, while the value rose 20% over that shipped in 1975. The unit value per ton increased $14.27. This increase in the unit value of kaolin exported was attributed to both the greater percentage of the higher quality paper-coating grades shipped and higher prices.

Kaolin, including calcined, was exported to 67 countries. The major recipients were Japan, 30%; Canada, 18%; Italy, 16%; West Germany, 11%; Mexico, 5%; and the remaining countries, 20%. Exports increased, except for those to Brazil, France, Taiwan, the United Kingdom, and West Germany. Kaolin producers reported the end use for their exports as follows: Paper coating, 33%; paper filling, 25%; refractories, 11%; rubber, 9%; and others, including adhesives, ceramics, paint, and plastics, 22%.

Kaolin imports in 1976 increased slightly from 19,126 tons valued at $773,000 in 1975 to 23,106 tons valued at $836,000. The United Kingdom supplied nearly 98%; Canada, 2%; and four other countries, less than 1%.

Kaolin prices quoted in the trade journals in 1976, except for the formulary grades, all advanced from 1975. Chemical Marketing Reporter, December 27, 1976, quoted prices as follows:

Waterwashed, fully calcined, bulk carload lots, f.o.b. Georgia, per ton	$145.00-$182.50
Paper-grade, uncalcined, same basis, per ton:	
No. 1 coating	61.50
No. 2 coating	47.00
No. 3 coating	43.00- 46.00
Filler, general purpose, same basis, per ton	30.00- 31.00
Delaminated, waterwashed, uncalcined, paint-grade, 1-micrometer average, same basis, per ton	115.00
Dry-ground, air-floated, soft, same basis, per ton	20.00
National formulary, powder, 50-pound bags, 5,000-pound lots, works, per pound	.07
National formulary, colloidal, 150-pound drums, works, per pound	.36

The average unit value reported by domestic kaolin producers was $46.17 per ton, an increase of $5.64 above the 1975 value.

[2]Pit & Quarry. Harris Mining Co. Acquires New Lands. V. 69, No. 4, October 1976, pp. 24-25.

Table 4.—Kaolin sold or used by producers in the United States, by State

State	1975 Short tons	1975 Value	1976 Short tons	1976 Value
Alabama	126,150	$3,491,648	134,408	$3,601,617
Arkansas	82,012	1,177,330	48,486	2,160,519
California	W	W	128,808	5,605,286
Florida	22,417	850,536	24,550	1,032,759
Georgia	4,016,927	177,611,861	4,924,648	250,864,949
Idaho	13,733	W	W	W
Missouri	104,636	W	67,519	1,067,600
Nevada	2,112	31,950	W	W
South Carolina	546,893	10,381,747	623,222	13,180,173
Other States[1]	419,269	22,630,797	176,119	5,390,466
Total	5,334,149	216,175,869	6,127,760	282,903,369

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Minnesota, North Carolina, Pennsylvania, Texas, Utah, and data indicated by symbol W.

Table 5.—Kaolin sold or used by producers in the United States, by kind

Kind	1975 Short tons	1975 Value	1976 Short tons	1976 Value
Airfloat	1,102,501	$23,182,773	1,252,433	$28,642,768
Calcined	885,274	59,164,183	1,067,931	75,034,960
Delaminated	277,209	17,547,878	396,444	27,494,005
Unprocessed	[1]749,044	[1]7,563,625	[1]624,629	[1]6,992,100
Waterwashed	2,320,121	108,717,410	2,786,323	144,739,536
Total	5,334,149	216,175,869	6,127,760	282,903,369

[1]Excludes calcined grades.

Table 6.—Calcined kaolin sold or used by producers in the United States in 1976, by kind

State	High temperature Short tons	High temperature Value	Low temperature Short tons	Low temperature Value
Georgia	542,895	$32,078,090	244,263	$30,011,375
Other States	[1]241,433	[1]10,399,025	[2]39,340	[2]2,546,470
Total	784,328	42,477,115	283,603	32,557,845

[1]Includes Alabama, Arkansas, and California.
[2]Includes Idaho, Pennsylvania, and Texas.

Table 7.—Georgia kaolin sold or used by producers, by kind

Kind	1975 Short tons	1975 Value	1976 Short tons	1976 Value
Airfloat	677,505	$12,560,862	746,037	$14,754,411
Calcined	478,103	36,305,591	787,158	62,089,465
Delaminated	277,209	17,547,878	396,444	27,494,005
Unprocessed	[1]330,667	[1]3,982,292	[1]256,740	3,852,894
Waterwashed	2,253,443	107,215,238	2,738,269	142,674,174
Total	4,016,927	177,611,861	4,924,648	250,864,949

[1]Excludes calcined grades.

Table 8.—Georgia kaolin sold or used by producers, by kind and use

(Short tons)

Use	1975 Airfloat	1975 Un-processed	1975 Water-washed[1]	1975 Total	1976 Airfloat	1976 Un-processed	1976 Water-washed[1]	1976 Total
Domestic:								
Adhesives	51,700	--	11,182	62,882	46,091	--	10,214	56,305
Alum (aluminum sulfate) and other chemicals	W	W	W	229,981	52,982	140,426	49,407	242,815
Animal feed	W	--	W	4,925	W	--	W	7,598
Catalysts (oil refining)	W	--	W	54,408	W	W	40,965	91,579
Cement, portland	--	W	--	W	--	W	--	W
Crockery and other earthenware	31,530	--	1,871	33,401	61,602	--	1,670	63,272
Electrical porcelain	6,113	--	1,171	7,284	2,564	--	1,469	4,033
Face brick	--	--	93	93	--	38,511	22	38,533
Fiberglass	81,215	--	70	81,285	86,313	--	--	86,313
Firebrick, block, and shapes	25,281	12,520	411	38,212	4,168	5,760	185	10,113
Floor and wall tile, ceramic	11,475	--	3,319	14,794	--	--	3,359	3,359
Flue linings and high-alumina brick	W	W	--	60,035	51,100	8,696	--	59,796
Foundry sand	859	--	--	859	861	--	24	885
Grogs and crudes, refractory	--	--	226,558	226,558	--	--	423,770	423,770
Ink	W	--	W	11,332	W	--	W	10,555
Medical, pharmaceutical, and cosmetic	222	--	535	757	502	--	1,567	2,069
Paint	3,800	--	88,208	92,008	78,985	--	92,543	171,528
Paper coating	13,614	--	1,428,621	1,442,235	14,168	--	1,570,235	1,584,403
Paper filling	169,211	--	434,701	603,912	92,635	--	733,470	826,105
Plastics	5,326	--	38,259	43,585	4,794	--	54,680	59,474
Pottery	--	--	W	W	--	--	W	W
Roofing granules	32,446	--	--	32,446	32,993	--	--	32,993
Rubber	79,917	--	8,590	88,507	72,489	--	8,861	81,350
Sanitary ware	47,287	W	W	88,973	40,511	W	W	65,377
Miscellaneous airfloat: China and dinnerware; fertilizer; glazes, glass and enamels; hobby ceramics; kiln furniture; mineral wool and insulation; pesticides and related products; roofing granules (1975); roofing tile; starch (1975); unknown uses	21,357	--	--	21,357	28,672	--	--	28,672
Miscellaneous, unprocessed: Sewer pipe and data indicated by symbol W	--	315,147	--	[2]82,962	--	58,744	--	[2]116,457
Miscellaneous, waterwashed: China and dinnerware; gypsum products; mineral oil filtering, clarifying and decolorizing; refractory mortar and cement; waterproofing and sealing; textiles; wire and cable; agriculture; unknown uses	--	--	33,016	33,016	--	--	99,236	99,236
Undistributed	76,747	--	93,435	([3])	58,555	--	92,791	([3])
Total	658,100	327,667	2,370,040	3,355,807	729,985	252,137	3,184,468	4,166,590

Exports:								
Foundry sand	--	--	W	W	--	--	116,525	116,525
Paint	--	--	13,052	13,052	--	--	16,038	16,038
Paper coating	3,400	--	349,518	352,918	6,730	--	298,465	305,195
Paper filling	5,590	--	114,144	119,734	402	--	230,271	230,673
Plastics	--	--	13,788	13,788	--	--	18,601	18,601
Refractories	8,400	--	134,427	142,827	8,400	--	1,279	9,679
Rubber	2,015	--	393	2,408	112	--	40,337	40,449
Undistributed	--	3,000	13,393	16,393	408	4,603	15,887	20,898
Total	19,405	3,000	638,715	661,120	16,052	4,603	737,403	758,058
Grand total	677,505	330,667	3,008,755	4,016,927	746,037	256,740	3,921,871	4,924,648

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1]Includes calcined and delaminated.
[2]Incomplete total; remainder included in totals for specific uses.

Table 9.—South Carolina kaolin sold or used by producers, by kind

Kind	1975 Short tons	1975 Value	1976 Short tons	1976 Value
Airfloat	372,417	$9,327,296	445,881	$12,084,315
Unprocessed	174,476	1,054,451	177,341	1,095,858
Total	546,893	10,381,747	623,222	13,180,173

Table 10.—South Carolina kaolin sold or used by producers, by kind and use

(Short tons)

Kind and use	1975	1976
Airfloat:		
Adhesives	24,808	19,329
Animal feed and pet absorbent	--	28,542
Ceramics[1]	13,000	12,560
Fertilizers	37,848	9,150
Fiberglass	30,200	53,369
Firebrick, block, and shapes	2,940	--
Paint	3,283	736
Paper filling	2,862	3,287
Pesticides and related products	23,990	25,136
Plastics	2,385	2,247
Rubber	185,966	215,941
Other refractories[2]	1,058	1,911
Other uses[3]	8,762	6,754
Exports[4]	35,315	66,919
Total	372,417	445,881
Unprocessed: Face brick; firebrick, block, and shapes; grogs and crudes, refractory (1975); and high alumina refractories	174,476	177,341
Grand total	546,893	623,222

[1]Includes floor and wall tile; roofing granules; sanitary ware; and miscellaneous.
[2]Includes high alumina refractories; mortar and cement, refractory; grogs and crudes, refractory; and miscellaneous.
[3]Includes common brick; crockery and other earthenware; drilling mud; linoleum; tile, asphalt and roof; and ink.
[4]Includes ceramics; pesticides and related products; plastics (1975); rubber; and miscellaneous.

BALL CLAY

Production and value reported for domestically mined ball clay in 1976 increased 13% and 16%. Tennessee provided 64% of the Nation's output, followed in order by Kentucky, Mississippi, Texas, Maryland, New York,[3] California, and Arizona. Production in Kentucky, Mississippi, New York, and Tennessee increased over that reported in 1975, but Arizona, California, Maryland, and Texas production decreased.

Ball clay is defined as a plastic, white-firing clay used principally for bonding in ceramic ware. The clays are of sedimentary origin and consist mainly of the clay mineral kaolinite and sericite micas.

In 1976, Kentucky-Tennessee Clay Co., Mayfield, Ky., completed an $800,000 expansion at its Gleason, Tenn., operation. American Olean Tile Co., Inc., a division of National Gypsum Co., sold its glazed tile plant in Pomona, Calif., to Pacific Holding Corp. The sale included manufacturing, warehouse, and office buildings, as well as two talc mines. The firm's plant and master distribution center at Roseville, Calif., was unaffected.[4]

The average unit value for ball clay reported by domestic producers rose in 1976 to $19.23 per ton, an increase of $0.45 per ton. Chemical Marketing Reporter, December 27, 1976, listed ball clay prices unchanged from 1975 as follows:

Domestic, air-floated, bags, carload lots, Tennessee, per ton	$18.00-$22.00
Domestic, crushed, moisture-repellent, bulk, carload lots, Tennessee, per ton	8.00- 11.25
Imported, air-floated, bags, carload lots, Atlantic ports, per ton	70.00
Imported, lump, bulk, Great Lakes, per ton	40.50

Ball clay exports in 1976 amounted to 157,000 short tons valued at $3.6 million compared with 156,000 tons worth $3.5 million in 1975. The tonnage exported, value, and unit value ($22.77) compared with 1975

[3]Albany slip clay is included with ball clay solely for statistical convenience.
[4]American Ceramic Society Bulletin. Newsnotes—American Olean Sells Plant. V. 55, No. 10, October 1976, pp. 945-946.

Table 11.—Kaolin sold or used by producers in the United States, by kind and use

(Short tons)

Use	1975 Airfloat	1975 Un-processed	1975 Water-washed[1]	1975 Total	1976 Airfloat	1976 Un-processed	1976 Water-washed[1]	1976 Total
Domestic:								
Adhesives	76,640	--	11,843	88,483	65,420	--	10,566	75,986
Alum (aluminum sulfate) and other chemicals	W	342,222	W	359,242	W	252,519	W	252,519
Animal feed	4,114	--	6,509	10,623	30,697	--	9,257	39,954
Brick, face	273	237,775	203	238,251	299	225,454	22	225,775
Catalysts (oil refining)	W	W	41,208	78,307	W	43,449	W	43,449
Cement, portland	--	36,187	18,508	54,695	W	W	W	17,170
Ceramic (hobby and artware)	W	W	--	13,276	W	W	--	2,062
China and dinnerware	6,114	--	17,995	24,109	7,081	--	14,164	21,195
Crockery and other earthenware	36,562	--	1,871	38,433	64,625	3,059	1,670	69,354
Electrical porcelain	11,609	--	2,089	13,698	11,947	--	1,469	13,416
Fertilizers[2]	W	--	W	53,075	9,399	W	W	20,186
Fiberglass	137,392	--	6,507	143,899	163,394	--	7,024	170,418
Firebrick, block, and shapes	28,313	16,780	157,815	202,908	4,186	9,573	185	13,944
Floor and wall tile, ceramic	18,916	--	3,467	22,383	8,299	--	3,359	11,658
Flue linings and high-alumina brick	W	W	--	60,215	51,300	20,012	--	71,312
Foundry sand	859	4,998	210	6,067	W	W	W	5,503
Glazes, glass, and enamels	W	--	W	4,642	W	--	W	3,937
Grogs and crudes, refractory	1,058	942	237,198	239,198	--	--	572,708	572,708
Gypsum products	1,247	--	1,650	2,897	1,227	--	3,574	4,801
Ink	W	--	W	11,865	W	--	W	11,211
Kiln furniture	1,886	--	--	1,886	1,646	--	--	1,646
Linoleum	23	--	--	23	350	--	--	350
Medical, pharmaceutical, and cosmetic	222	--	535	757	502	--	1,567	2,069
Mortar and cement, refractory	--	1,110	729	1,839	1,711	21,107	592	23,410
Paint	7,083	--	107,518	114,601	79,721	22,900	108,681	211,302
Paper coating	13,614	--	1,430,426	1,444,040	14,168	--	1,570,235	1,584,403
Paper filling	173,562	--	434,701	608,263	92,635	--	826,105	918,740
Pesticides and related products	28,320	--	3,794	32,114	27,070	6,561	--	33,631
Plastics	7,711	--	38,259	45,970	7,041	--	54,680	61,721
Pottery	3,750	W	W	8,644	W	--	W	41,772
Roofing granules	32,446	--	--	32,446	33,403	--	--	33,403
Rubber	265,883	--	17,584	283,467	288,430	--	15,189	303,619
Sanitary ware	60,891	W	W	104,076	53,172	W	W	81,851
Textiles	--	--	1,842	1,842	--	--	1,480	1,480
Waterproofing and sealing	10	--	--	10	W	--	W	197
Miscellaneous	126,346	106,030	96,085	[3]83,190	148,573	411	231,848	[3]259,514
Total	1,044,844	746,044	2,638,546	4,429,434	1,166,246	605,045	3,434,375	5,205,666

See footnotes at end of table.

Table 11.—Kaolin sold or used by producers in the United States, by kind and use —Continued

(Short tons)

Use	1975				1976			
	Airfloat	Un-processed	Water-washed[1]	Total	Airfloat	Un-processed	Water-washed[1]	Total
Exports:								
Ceramics	2,937	3,000	3,488	9,425	W	W	--	11,253
Chemical manufacturing	--	--	428	428	--	--	--	--
Grogs, crudes, and other refractories	8,400	--	336,812	345,212	8,400	--	95,180	103,580
Paint	--	--	13,052	13,052	--	--	16,038	16,038
Paper coating	3,400	--	349,518	352,918	6,730	--	298,465	305,195
Paper filling	5,590	--	114,144	119,734	402	--	230,271	230,673
Plastics	900	--	13,788	14,688	--	--	18,601	18,601
Rubber	36,165	--	393	36,558	45,773	14,981	25,356	86,110
Other	265	--	12,435	12,700	24,882	4,603	132,412	[3]150,644
Total	57,657	3,000	844,058	904,715	86,187	19,584	816,323	922,094
Grand total	1,102,501	749,044	3,482,604	5,334,149	1,252,433	624,629	4,250,698	6,127,760

W Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous."
[1]Includes calcined and delaminated.
[2]Includes soil conditioners and mulches.
[3]Incomplete total; remainder included with totals for specific uses.

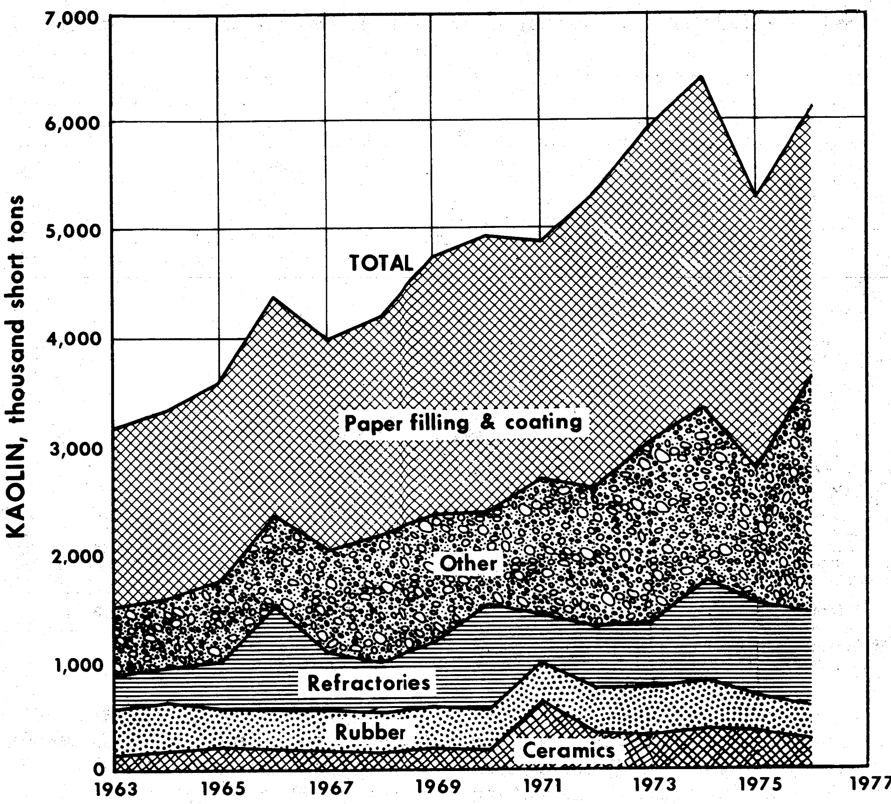

Figure 1.—Kaolin sold or used by domestic producers for specified uses.

Table 12.—Ball clay sold or used by producers in the United States, by type and State

Year and State	Airfloat		Unprocessed		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1975						
Tennessee	262,987	$5,482,026	161,357	$2,367,277	424,344	$7,849,303
Texas	--	--	54,698	466,810	54,698	466,810
Other States	[1]163,283	[1]4,093,978	[2]63,922	[2]854,956	227,205	4,948,934
Total	426,270	9,576,004	279,977	3,689,043	706,247	13,265,047
1976						
Tennessee	295,777	6,290,301	217,968	3,706,073	513,745	9,996,374
Texas	549	9,300	15,224	99,900	15,773	109,200
Other States	[1]194,409	[1]4,391,663	[2]76,944	[2]907,140	271,353	5,298,803
Total	490,735	10,691,264	310,136	4,713,113	800,871	15,404,377

[1]Includes Kentucky, Maryland, and Mississippi.
[2]Includes Arizona, California, Kentucky, Mississippi, and New York.

Table 13.—Ball clay sold or used by producers in the United States, by kind and use

(Short tons)

Use	1975			1976		
	Air-float	Un-processed	Total	Air-float	Un-processed	Total
Adhesives	1,003	--	1,003	782	--	782
Alum (aluminum sulfate) and other chemicals	441	--	441	--	--	--
Animal feed	544	--	544	W	--	W
Brick, face	--	12,000	12,000	--	W	W
Ceramic (hobby and artware)	6,334	--	6,334	--	--	--
China and dinnerware	35,330	1,265	36,595	50,664	--	50,664
Crockery and other earthenware	--	914	914	2,650	1,216	3,866
Drilling mud	W	W	2,564	W	--	W
Electrical porcelain	23,984	22,917	46,901	W	W	29,470
Firebrick, block, and shapes	--	30,461	30,461	--	5,738	5,738
Glazes, glass, and enamels	W	W	1,786	W	W	2,803
High-alumina refractories	W	W	21,100	W	W	20,700
Kiln furniture	W	W	8,297	W	W	7,476
Medical, pharmaceutical, and cosmetic	483	1	484	--	--	--
Paint	157	--	157	--	--	--
Pesticides and related products	1,348	--	1,348	W	--	W
Pottery	99,492	27,945	127,437	174,142	87,110	261,252
Rubber	240	--	240	W	--	W
Sanitary ware	24,901	72,371	97,272	14,624	63,749	78,373
Sewer pipe	--	112	112	--	465	465
Tile:						
Floor and wall	82,792	29,752	112,544	68,915	22,473	91,388
Quarry	--	914	914	--	992	992
Other	--	3	3	326	2,494	2,820
Miscellaneous	62,276	62,533	[1]91,062	87,232	110,486	[1]137,269
Exports	86,945	18,789	105,734	91,400	15,413	106,813
Total	426,270	279,977	706,247	490,735	310,136	800,871

W Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous."
[1]Incomplete total; remainder included with total for each specific use.

were essentially unchanged. These shipments were made to 19 countries. The major recipients were Canada, 55% and Mexico, 41%; 17 countries accounted for the remaining 4%.

Ball clay imports, all from the United Kingdom, decreased slightly from 11,903 tons valued at $366,000 in 1975 to 10,644 tons valued at $342,000.

FIRE CLAY

Fire clay sold or used by domestic producers in 1976 was reported at 3,352,250 tons valued at $40.1 million. Fire clay is defined as detrital material, either plastic or rock-like, containing low percentages of iron oxide, lime, magnesia, and alkalies to enable the material to withstand temperatures of 1,500° C or higher. Fire clay is basically kaolinite but usually contains other materials such as diaspore, ball clay, bauxite clay, and shale. Fire clays commonly occur as underclay below coal seams, and thus are generally used for refractories. Some fire clay was previously reported in other end uses.

Fire clay production was reported in 1976 from mines in 18 States. The first four States in rank, Pennsylvania, Missouri, Ohio, and Alabama, accounted for 81% of the total domestic output.

Swank Refractories Co., Johnstown, Pa., acquired the operation of H. K. Porter Co.'s ladle brick division. Porter's primary product is fire clay brick. The acquisition includes four major refractories, manufacturing plants, and a large underground mine.[5] Harbison-Walker Refractories Div. of Dresser Industries, Inc., opened a new high-alumina refractory production line at Clearfield, Pa., No. 3 works. This will be the first time Harbison's new generation, high-alumina refractories are manufactured in the Northeast.[6]

Exports of fire clay increased from 219,000 tons worth $7.2 million in 1975, to 296,000 tons valued at $12.9 million in 1976. Fire clay exports increased over 35% in tonnage and rose 79% in value. The price of exported fire clay rose by $10.73 to $43.57 per ton.

Fire clay was exported to 40 countries,

[5]Iron Age. Industry Briefs—Mergers and Acquisitions. V. 218, No. 23, Dec. 6, 1976, p. 33.
[6]Iron and Steel Engineer. Industry News—New Harbison-Walker Production Line. V. 53, No. 11, November 1976, p. 106.

with Canada, Mexico, and West Germany receiving 33%, 22%, and 15%. No imports of fire clay were reported during 1976.

There are no price quotations in domestic journals for fire clay, but the per-ton value reported by producers ranged from $3 to about $50. The reported average unit value for fire clay produced in the United States increased 9% from $11.01 per ton in 1975 to $11.97 in 1976.

Table 14.—Fire clay sold or used by producers in the United States, by State[1]

State	1975		1976	
	Short tons	Value	Short tons	Value
Alabama	249,310	$3,057,100	372,971	$4,049,077
California	105,246	424,346	86,189	383,648
Colorado	26,559	110,206	29,317	421,722
Georgia	3,890	21,800	9,941	59,680
Illinois	56,635	393,162	50,883	381,752
Indiana	1,617	15,640	2,065	20,780
Kentucky	95,925	621,747	85,814	580,457
Missouri	854,169	11,285,147	809,273	11,723,406
Montana	1,345	W	1,266	5,792
New Jersey	17,319	121,850	11,549	80,712
Ohio	796,758	5,834,312	700,078	5,330,220
Pennsylvania	781,134	10,362,015	838,757	11,928,949
Texas	34,248	270,590	54,335	259,580
Utah	5,110	29,880	4,590	26,889
Other States[2]	233,743	3,384,058	295,222	4,866,308
Total	3,263,008	35,931,853	3,352,250	40,118,972

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Refractory uses only.
[2]Includes Arizona (1975), Idaho, New Mexico, Washington, West Virginia, and data indicated by symbol W.

BENTONITE

Bentonite production in 1976 increased 9% in tonnage and 16% in value over that of 1975. A general increase in domestic consumption, particularly in filtering, decolorizing, waterproofing and sealing, and exports was noted along with a large increase in drilling mud and slight increases in animal feed and pet absorbent.

Bentonite was produced in 15 States. Increased bentonite production was reported for Alabama, Arizona, California, Colorado, Idaho, Kansas, Mississippi, Nevada, Oregon, South Dakota, Tennessee, Utah, and Wyoming. Production decreased in Montana and Texas.

Generally, the high-swelling or sodium bentonites are produced chiefly in Wyoming, Montana, and South Dakota. The calcium or low-swelling bentonites are produced in the other States.

Industrial Mineral Ventures, Inc., reported to have invested up to $12 million in its Amargosa Valley, Nev., sepiolite, saponite, and hectorite mining and milling operations.[7] Industrywide improvements were continuing to be made in environmental controls systems and in automating, bagging, and handling procedures. Some experimental work was also underway exploring the practicality of switching from oil and gas firing in dryers to coal burning.

On December 27, 1976, Chemical Marketing Reporter quoted bentonite prices unchanged. Domestic, 200-mesh, bags, carload lots, f.o.b. mines, was priced from $15.50 to $16.00 per ton; and imported Italian, white, high-gel, bags, 5-ton lots, ex-warehouse, $337.60 ($0.1688 per pound) per ton. The average unit value reported by domestic producers for bentonite sold or used in 1976 was $16.61, an increase of $0.98 from the $15.63 average of 1975. Per-ton values reported in the various producing States ranged from $4 to $41 but, as in 1975, the average value reported by the larger producers was near the Mississippi average figure of $18.05.

Bentonite exports in 1976 increased from 697,000 tons in 1975 to 787,000 tons; value increased from $39.5 million in 1975 to $50.4 million in 1976. Although the tonnage exported increased nearly 13% above that shipped in 1975, the value increased 28%.

[7]Nevada West and Pahrump Times (South Las Vegas, Nev.). V. 6, No. 1, January 1976, pp. 1, 10-11.

The increase in value was the result of increase in the unit value of exported bentonite from $56.60 per ton in 1975 to $64.04 per ton in 1976. This increase in per-ton value was attributed to a large increase in the value of the higher cost drilling mud and foundry-grade bentonites shipped. Exports in previous years consisted of a larger percentage of the lower cost pelletizing grades. Domestic bentonite producers were facing increased competition in foreign markets. Bentonite from the Greek Island of Milos was being blended with the U.S. clay for pelletizing Canadian taconite ores on a large scale.

Bentonite was again exported to 83 countries. The major recipients were Canada, 50%; Japan, 10%; West Germany, 9%; the United Kingdom, 6%; Australia, 4%; and the others, 21%. Domestic bentonite producers reported the end use of their exports were foundry sand, 43%; drilling mud, 33%; iron ore pelletizing, 22%; and others (including medical, pharmaceutical, cosmetic, soil conditioner, and rubber), 2%.

Bentonite imports in 1976, including chemically activated material, totaled 2,945 tons valued at $466,000 compared with 5,219 tons valued at $617,000 in 1975. The 2,849 tons of chemically activated bentonite was imported from seven countries, with Mexico supplying 36%; Canada, 33%; Japan, 29%; and West Germany, France, the Philippines, and the United Kingdom the remaining 2%. Special-purpose Italian bentonite was also imported in 1976.

Table 15.—Bentonite sold or used by producers in the United States, by type and State

State	Nonswelling		Swelling		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1975						
Arizona	W	W	W	W	25,118	$315,554
California	22,879	$588,228	49,017	$1,459,862	71,896	2,048,090
Colorado	--	--	2,506	26,241	2,506	26,241
Mississippi	264,039	4,607,219	--	--	264,039	4,607,219
Montana	--	--	177,424	1,800,383	177,424	1,800,383
Nevada	--	--	2,858	104,366	2,858	104,366
Oregon	--	--	1,199	14,388	1,199	14,388
Texas	W	W	--	--	W	W
Utah	812	15,428	300	600	1,112	16,028
Wyoming	--	--	2,404,169	35,623,075	2,404,169	35,623,075
Other States	[1]186,776	[1]3,806,710	[2]117,288	[2]2,428,544	[3]278,946	[3]5,919,700
Total	474,506	9,017,585	2,754,761	41,457,459	3,229,267	50,475,044
1976						
Arizona	W	W	W	W	27,921	361,386
California	28,902	747,032	58,822	1,900,980	87,724	2,648,012
Colorado	1,200	12,000	W	W	W	W
Mississippi	373,457	6,739,559	--	--	373,457	6,739,559
Montana	--	--	158,695	2,304,871	158,695	2,304,871
Nevada	--	--	7,512	174,300	7,512	174,300
Oregon	--	--	1,814	29,024	1,814	29,024
Texas	39,414	850,344	--	--	39,414	850,344
Utah	--	--	2,000	8,000	2,000	8,000
Wyoming	--	--	2,495,797	39,514,743	2,495,797	39,514,743
Other States	[1]154,130	[1]2,254,203	[2]198,638	[2]3,929,505	[3]326,047	[3]5,834,322
Total	597,103	10,603,138	2,923,278	47,861,423	3,520,381	58,464,561

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Alabama and data indicated by symbol W.
[2]Includes Idaho (1976), Kansas (1976), South Dakota, Tennessee (1976), and data indicated by symbol W.
[3]Incomplete total; remainder included with totals for specific States.

Table 16.—Bentonite sold or used by producers in the United States, by type and use

(Short tons)

Use	1975 Non-swelling	1975 Swelling	1975 Total	1976 Non-swelling	1976 Swelling	1976 Total
Domestic:						
Adhesives	--	3	3	W	W	1,583
Animal feed	49,774	126,284	176,058	--	156,652	156,652
Brick, face	--	1,135	1,135	--	--	--
Catalysts (oil refining)	7,418	42	7,460	2,208	9	2,217
Cement, portland	--	336	336	--	250	250
Drilling mud	25,809	710,446	736,255	23,451	950,099	973,550
Fertilizers	8,406	--	8,406	9,160	--	9,160
Filtering, clarifying, and decolorizing:						
Animal oils and mineral oils and greases	48,823	5,687	54,510	32,638	3,969	36,607
Vegetable oils	63,876	--	63,876	158,334	--	158,334
Foundry sand	242,133	465,800	707,933	288,769	357,704	646,473
Glazes, glass, and enamels	--	141	141	--	W	W
Gypsum products	--	383	383	--	470	470
Medical, pharmaceutical, and cosmetic	58	2,019	2,077	--	1,533	1,533
Paint	--	4,102	4,102	W	W	3,570
Pelletizing (iron ore)	--	878,022	878,022	--	868,947	868,947
Pesticides and related products	2,462	517	2,979	3,556	50	3,606
Pet absorbent	--	30,134	30,134	--	35,416	35,416
Tile:						
Floor and wall	488	--	488	477	--	477
Roofing	7,566	--	7,566	15,470	--	15,470
Other	--	--	--	31,052	1,925	32,977
Waterproofing and sealing	1,820	33,629	35,449	2,402	63,389	65,791
Miscellaneous	3,052	61,984	65,036	187	13,766	[1]8,800
Total	461,685	2,320,664	2,782,349	567,704	2,454,179	3,021,883
Exports:						
Drilling mud	--	128,848	128,848	--	184,572	184,572
Foundry sand	12,821	154,391	167,212	16,331	153,749	170,080
Pelletizing (iron ore)	--	142,839	142,839	--	129,596	129,596
Other	--	8,019	8,019	13,068	1,182	14,250
Total	12,821	434,097	446,918	29,399	469,099	498,498
Grand total	474,506	2,754,761	3,229,267	597,103	2,923,278	3,520,381

W Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous."

[1]Incomplete total; remainder included with total for each specific use.

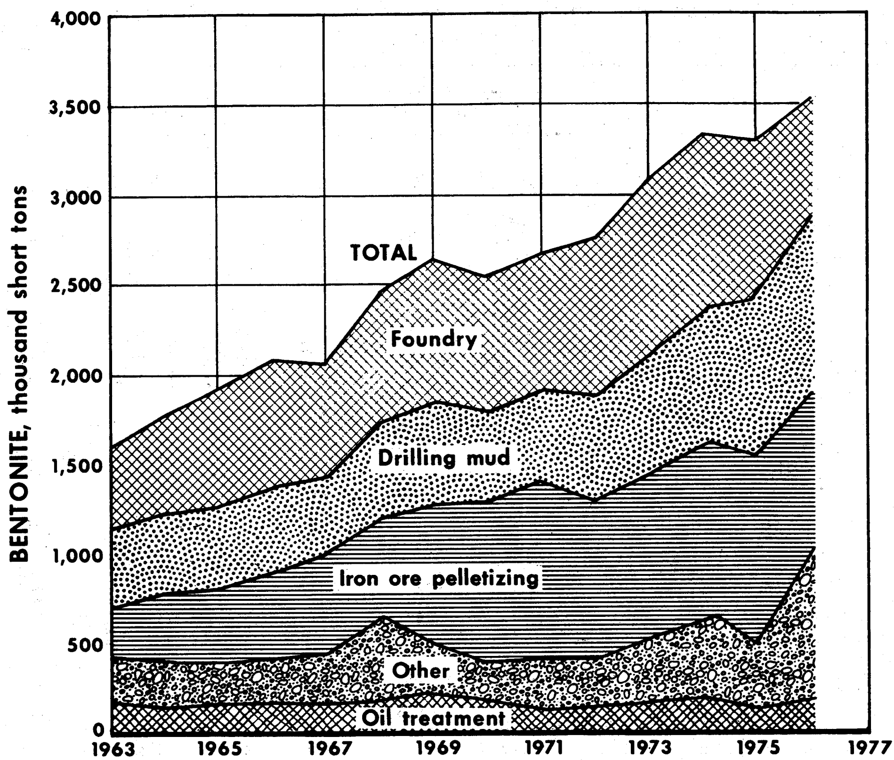

Figure 2.—Bentonite sold or used by domestic producers for specified uses.

FULLER'S EARTH

Production of fuller's earth in 1976 increased 13% in quantity and 23% in value. The unit value assigned by domestic producers increased $3.35 in 1976 to $39.09 per ton. This increase in value was due to large increases in unit value by Florida, Georgia, Illinois, Mississippi, and South Carolina producers.

Fuller's earth production was reported from operations in nine States. The two top producing States, Georgia (39%) and Florida (31%), accounted for 70% of the domestic production. The other seven States accounted for the remaining 30%. All States showed slight gains in production. California and Missouri did not report any production in 1976.

Fuller's earth is defined as a nonplastic clay or claylike material, usually high in magnesia, which has adequate decolorizing and purifying properties.

Production from the region that includes Attapulgus (Decatur County), Ga., and Quincy (Gadsden County), Fla., is composed predominantly of the distinct lath-shaped amphibole clay mineral attapulgite. Most of the fuller's earth produced in the other areas of the United States contains varieties of montmorillonite.

Prices for fuller's earth were not publicly quoted in 1976, but the value per ton for attapulgite reported by producers ranged from $25 to over $55; montmorillonite prices ranged from $21 to $46.

The tonnage, value, and unit value of fuller's earth exported to 36 countries were unchanged from 1975. The unit value of exported fuller's earth declined $3.07

to $64.48 per ton. The major recipients were the United Kingdom, 33%; Canada, 21%; the Netherlands, 19%; and other countries, the remaining 27%.

Imports of fuller's earth in 1976 were 22 tons valued at $2,000 all from the United Kingdom.

Table 17.—Fuller's earth sold or used by producers in the United States, by type and State

Year and State	Attapulgite		Montmorillonite		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1975						
Florida	384,550	$15,755,032	--	--	384,550	$15,755,032
Georgia	W	W	W	W	446,413	14,273,864
Utah	--	--	2,174	$49,000	2,174	49,000
Other States	[1]334,884	[1]12,619,197	[2]467,456	[2]14,075,347	[3]355,927	[3]12,420,680
Total	719,434	28,374,229	469,630	14,124,347	1,189,064	42,498,576
1976						
Florida	412,832	19,006,753	--	--	412,832	19,006,753
Georgia	345,249	14,159,671	176,037	3,755,858	521,286	17,915,529
Nevada	W	W	--	--	W	W
Utah	--	--	2,238	55,950	2,238	55,950
Other States	[1]24,140	[1]1,184,481	[2]381,086	[2]14,276,302	405,226	15,460,783
Total	782,221	34,350,905	559,361	18,088,110	1,341,582	52,439,015

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Texas and data indicated by symbol W.
[2]Includes Illinois, Mississippi, Missouri (1975), South Carolina, Tennessee, Texas and data indicated by symbol W.
[3]Incomplete total; remainder included in Georgia.

Table 18.—Fuller's earth sold or used by producers in the United States, by type and use

(Short tons)

Use	1975			1976		
	Attapulgite	Montmorillonite	Total	Attapulgite	Montmorillonite	Total
Domestic:						
Adhesives	5,030	--	5,030	3,278	--	3,278
Animal feed	40	--	40	202	--	202
Cement, portland	W	W	17,632	W	W	50,244
Drilling mud	87,981	--	87,981	74,824	5,478	80,302
Fertilizers	30,840	12,065	42,905	35,652	9,309	44,961
Filtering, clarifying, and decolorizing mineral oils and greases	22,262	--	22,262	22,674	2,113	24,787
Medical, pharmaceutical, and cosmetic	61	--	61	51	--	51
Oil and grease absorbents	200,934	148,141	349,075	270,222	120,954	391,176
Paint	2,063	--	2,063	2,791	--	2,791
Paper coating	4	--	4	150	--	150
Pesticides and related products	149,077	49,250	198,327	154,180	50,839	205,019
Pet absorbent	151,578	222,864	374,442	127,588	294,722	422,310
Rubber	4	--	4	5	--	5
Miscellaneous	8,088	19,051	[1]9,507	26,510	44,978	[1]21,244
Total	657,962	451,371	1,109,333	718,127	528,393	1,246,520
Exports:						
Catalysts (oil refining)	W	W	3,280	--	--	--
Drilling mud	W	--	W	457	--	457
Fertilizers	W	W	2,039	--	--	--
Oil and grease absorbents	17,077	4,544	21,621	31,923	141	32,064
Pet absorbent	32,311	5,734	38,045	23,218	22,830	46,048
Miscellaneous	12,084	7,981	[1]14,746	8,496	7,997	16,493
Total	61,472	18,259	79,731	64,094	30,968	95,062
Grand total	719,434	469,630	1,189,064	782,221	559,361	1,341,582

W Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous."
[1]Incomplete total; remainder included with total for each specific use.

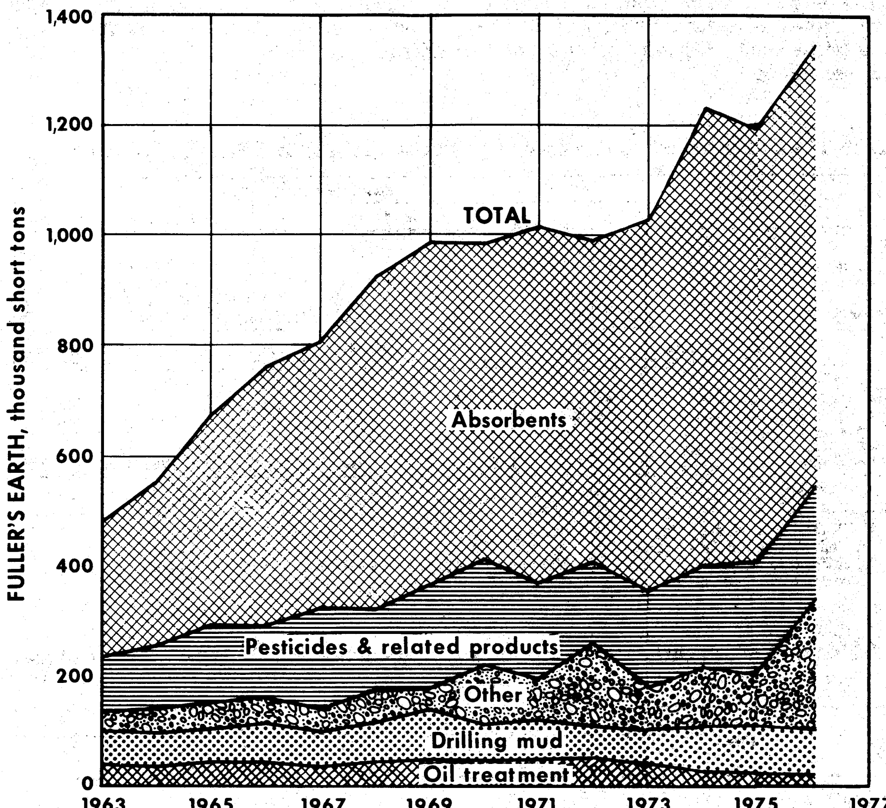

Figure 3.—Fuller's earth sold and used by domestic producers for specified uses.

COMMON CLAY

Domestic production of common clay and shale in 1976 totaled 37.6 million tons valued at $79.8 million. Common clay and shale represented 71% of the quantity and 15% of the value of the total clays in 1976. Puerto Rican production and value of common clay and shale were withheld to avoid disclosing confidential company data. Domestic output in 1976 increased 5% above that reported for 1975.

Common clays and shales are for the most part used by the producer in fabricating or manufacturing products. Less than 10% of the total clay and shale output was sold. The average unit value for all common clay and shale produced in the United States and Puerto Rico in 1976 was $2.12 per short ton, $0.25 more than in 1975. The range in unit value reported for the bulk of the output was from $1 to $5 per ton.

Common clay is defined as a clay or claylike material which is sufficiently plastic to permit ready mold and vitrification below 1,100° C. Shale is consolidated sedimentary rock composed chiefly of clay minerals that has been both laminated and indurated while buried under other sediments. These materials are used in the manufacture of structural clay products, such as brick and drain tile, portland cement clinker, and bloated lightweight aggregate.

In 1976, Dickey Co., Pittsburg, Kans., announced that it and Hepworth Ceramic Holdings, Ltd., had reached an agreement to merge with a U.S. subsidiary of Hepworth. Dickey is a large Midwest manufacturer of large-diameter clay sewer pipe. The output of the energy-intensive common clay and shale industry was hindered again by shortages of fuel and labor. Construction rates increased in 1976. Industry-wide attention was focusing on coal firing as a possible escape from the high cost and shortages of oil and gas.

Exports of common clay and shale are not tallied by the U.S. Department of Commerce. Most countries have local deposits of either clays or shales that are adequate for manufacturing structural clay products, cement clinker, and lightweight aggregates, and thus have no need to import such materials.

Table 19.—Common clay and shale sold or used by producers in the United States, by State[1]

State	1975		1976	
	Short tons	Value	Short tons	Value
Alabama	1,855,246	$2,528,551	1,731,341	$2,674,718
Arkansas	913,180	1,054,415	998,033	1,235,755
California	2,209,828	4,900,763	1,992,487	4,928,352
Colorado	451,050	964,382	450,202	1,554,488
Connecticut	115,633	306,531	130,483	427,080
Delaware	9,396	5,638	11,241	7,900
Florida	305,519	456,976	242,638	632,326
Georgia	1,689,236	3,392,463	2,015,540	4,305,011
Illinois	1,309,501	2,855,606	1,258,136	2,889,933
Indiana	1,092,023	1,944,931	1,262,642	2,287,649
Iowa	959,311	1,916,060	1,016,772	2,244,873
Kansas	1,177,605	1,603,860	1,063,831	1,868,714
Kentucky	681,789	861,398	668,425	1,814,500
Louisiana	530,925	1,132,291	512,572	1,158,137
Maine	125,474	202,380	133,617	216,060
Maryland	580,346	1,450,124	702,361	1,816,949
Massachusetts	124,364	227,593	125,934	237,706
Michigan	1,818,102	3,579,774	1,934,334	4,741,192
Mississippi	1,152,322	1,974,623	1,113,723	2,109,552
Missouri	1,209,273	1,928,433	1,256,298	2,123,604
Montana	44,679	77,378	31,660	45,971
Nebraska	194,975	416,386	149,275	344,683
New Jersey	50,000	250,000	50,000	250,000
New Mexico	43,848	60,669	55,926	116,086
New York	817,136	1,561,094	649,543	2,089,523
North Carolina	2,581,960	4,093,650	2,750,011	4,677,254
Ohio	2,654,073	5,987,325	3,587,644	9,373,707
Oklahoma	995,200	1,700,763	1,154,656	1,678,247
Oregon	118,345	199,647	145,258	286,407
Pennsylvania	1,164,167	3,309,590	1,452,729	4,108,000
Puerto Rico	341,342	440,117	W	W
South Carolina	1,150,685	2,446,479	1,631,062	3,457,856
South Dakota	187,354	184,549	123,842	137,066
Tennessee	885,937	1,159,053	1,015,924	1,581,536
Texas	3,994,529	7,593,599	3,596,912	7,627,532
Utah	211,275	453,087	197,340	440,094
Virginia	819,458	1,152,034	862,036	1,210,199
Washington	289,693	777,761	380,856	1,140,537
West Virginia	278,300	439,165	275,138	463,583
Wisconsin	2,400	4,416	W	W
Wyoming	177,973	422,558	201,440	500,460
Other States[2]	352,834	633,835	647,770	1,025,138
Total	35,666,286	66,649,947	37,579,632	79,828,378

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1]Includes Puerto Rico.

[2]Includes Arizona, Hawaii, Idaho, Minnesota, Nevada, New Hampshire, North Dakota, and data indicated by symbol W.

CONSUMPTION AND USES

The manufacture of heavy clay products (building brick, sewer pipe, drain, roofing, structural, terra cotta, and other tile), portland cement and clinker, and lightweight aggregate accounted for 38%, 21%, and 12%, respectively, of the total domestic consumption for 1976. In summary, 71% of all clay produced in 1976 was consumed in the manufacture of these clay- and shale-based construction materials. The foregoing clay tonnage relationships were similar to those reported for 1975. The utilization of clays in 1976 for heavy clay products and portland cement increased 14% and 12%, respectively, over that reported in 1975.

Heavy Clay Products.—The values reported for shipments of heavy clay products in 1976 increased 20% to $784 million from the 1975 value of $656 million. Trends in the various product categories were less consistent. Thousand-unit counts for building or common face brick increased 19% in 1976 from that shipped in 1975; shipments of glazed and unglazed ceramic tile and glazed brick decreased 22%, and clay floor and wall tile increased 10%. The tonnage of unglazed structural tile decreased 19%, and vitrified clay sewer pipe and fittings shipped during the year declined 8%. The value of these shipments increased 29% for building brick and clay and 17% for floor and wall tile. The value declined less than 1% for clay sewer pipe and over 13% for the structural tiles.

Lightweight Aggregate.—Consumption of clay and shale in the making of lightweight aggregate declined in 1976 to 6,180,643 tons. This was a 24% decrease from the 8.1 million tons used in 1975.

The tonnage of raw material mentioned in tables 20 and 23 for lightweight aggregate production refers only to clay and shale and does not include the quantity of slate and blast furnace slag similarly used. In 1976, 523,000 tons of slate was expanded for lightweight aggregate, 3% above the 1975 figure of 510,000 tons. The National Slag Association reported that the amount of slag used for lightweight concrete aggregate and in block manufacture increased 37% from 1,092,000 tons in 1975 to 1,492,000 tons in 1976.

Refractories.—All types of clay were used in manufacturing refractories. Fire clay, kaolin, and bentonites accounted for 59%, 17%, and 13%, respectively, of the total clays used for this purpose. Bentonite was used primarily as a bonding agent in proprietary foundry formulations. Minor tonnages of ball clay (2%), fuller's earth, and common clay and shale (the remaining 9%) were also used, primarily as bonding agents.

The tonnage used for refractories in 1976 increased to slightly more than 9% of the total clays produced. This slight increase in the use of clay-based refractories continued for a fifth year, a reversal in the downward pattern set for a number of years. The increase was due primarily to both the continued expansion in refractory aggregate production and an upsurge in the manufacturing of more conventional brick-type refractories. Refractory aggregates are used mostly in plastic, gunning, ramming, and castable mixes.

Filler.—All clays are used to some extent as fillers in one or more areas of use. Kaolin, fuller's earth, and bentonite are the principal filler clays. Kaolin was used in the manufacture of a large number of products, such as paper, rubber, plastics, paint, and fertilizers. Fuller's earth was used primarily in pesticides and fertilizers. Clays in pesticides and fertilizers are used either as carriers, diluents, or prilling agents. Bentonites were used mainly in animal feed.

Seven percent of the clay produced in 1976 was used in filler applications. Of all the clay used for these purposes, kaolin accounted for 72%, fuller's earth 5%, and bentonite 4%. Ball clay and common clay and shale accounted for the remaining 19%. The total amount of kaolin consumed by this end use category increased 23%. In the individual kaolin categories, increases of over 100% were recorded in animal feeds and medical, pharmaceutical, and cosmetic categories. Other increases were paint (84%), gypsum products (66%), paper filling (51%), plastics (34%), paper coating (9%), and rubber (7%). Total quantity of fuller's earth used in insecticides and fungicides increased 3%.

Absorbent Uses.—Absorbent uses for clays, 1,156,455 tons, consumed 2% of the total 1976 clay production. Demand for absorbents in 1976 increased 53% over that reported for 1975. Fuller's earth was the principal clay used in absorbent applications; 62% of the entire output was consumed for this purpose. Bentonite was used to a lesser degree. Demand for clays in pet absorbent, representing 31% of the 1976 absorbent demand, increased 13% from that reported for 1975. Demand for use in floor absorbents, chiefly to absorb hazardous oily substances, represented the remaining 56% of absorbent demand and increased 25% from the 1975 figure.

Drilling Mud.—Demand for clays in rotary-drilling muds increased 27% in 1976, from 827,962 tons in 1975 to 1,049,745 tons. This increase in demand, mostly in exploratory gas well drilling and to a lesser degree in oil well drilling, was spurred by the deregulation of "new" gas introduced into the interstate market after April 6, 1972. Drilling muds consumed 2% of the entire 1976 clay production. Swelling-type bentonite is the principal clay used in drilling mud mixes, although fuller's earth or nonswelling bentonite is also used to a limited extent. Bentonite and fuller's earth accounted for nearly 100% of the total amount of clay used for this purpose. Small amounts of ball clay, common clay and shale, and koalin were used in specialized formulations.

Floor and Wall Tile.—Common clay and shale, ball clay, koalin, fire clay, and bentonite, in order of demand, were used in manufacturing floor, wall, and quarry tile. This tile end use category accounted for less than 1% of the total clay production in 1976. Demand in 1976, 381,641 tons, decreased 4% from that shown in 1975.

Pelletizing Iron Ore.—Bentonite is used as a binder in forming iron ore pellets. Demand decreased slightly in 1976 to 868,947 tons. This decrease in the use of bentonite for iron ore pelletizing, reflecting a downturn in steel production, was compounded by inroads made by cheaper foreign bentonites into a traditional U.S. clay market. Of the total bentonite produced in 1976, about 30% of the swelling variety was consumed for this purpose. U.S. deposits continued to be the major source for swelling bentonites.

Ceramics.—The total demand for clays in the manufacture of pottery, sanitary ware, china and dinnerware, and related products, excluding clay flower pots, accounted for 2% of the total 1976 clay output. The total clay demand, principally ball and kaolin clays, increased from approximately 616,000 tons in 1975 to approximately 1,052,343 tons in 1976.

Table 20.—Clays sold or used by producers in the United States in 1976, by kind and use, including Puerto Rico

(Short tons)

Use	Ball clay	Bentonite	Common clay and shale	Fire clay (refractory only)	Fuller's earth	Kaolin	Undistributed[1]	Total
Adhesives	782	1,583	--	--	3,278	75,986	--	81,629
Alum (aluminum sulfate) and other chemicals	--	--	--	--	--	252,519	--	252,519
Animal feed	(3)	156,652	--	--	202	39,954	--	[4]196,808
Asphalt emulsion and tiles	(3)	(3)	--	--	--	(3)	36,598	36,598
Building brick:								
Common	(3)	(3)	3,507,451	(3)	--	60,753	6,919	3,575,123
Face	(3)	--	14,026,947	140,815	--	225,775	--	[4]14,393,537
Catalysts (oil refining)	(3)	2,217	(3)	--	--	43,449	41,825	87,491
Cement, portland	--	250	11,015,348	--	50,244	17,170	--	11,083,012
Ceramic (hobby and artware)	--	--	60	--	--	2,062	--	2,122
China and dinnerware	50,664	--	--	--	--	21,195	--	71,859
Crockery and other earthenware	3,866	(3)	4,425	(3)	(3)	69,354	27,556	105,201
Drilling mud	(3)	973,550	1,239	--	80,302	22	--	[4]1,055,113
Electrical porcelain	29,470	--	--	--	--	13,416	--	42,886
Fertilizers	274	9,160	19,326	--	44,961	20,186	--	93,907
Fiberglass	--	--	--	--	--	170,418	--	170,418
Filtering, clarifying, decolorizing:								
Animal oil	--	(3)	--	--	(3)	--	18,149	18,149
Mineral oils and greases	--	18,814	--	--	24,787	--	--	43,601
Vegetable oils	--	158,334	--	--	--	--	--	158,334
Firebrick, block, and shapes	5,738	7,696	2,341	2,118,523	--	13,944	--	2,148,242
Flower pots	(3)	--	35,673	(3)	--	--	18,090	53,763
Flue linings	--	--	100,132	76,412	--	8,696	--	185,240
Foundry sand	--	646,473	--	123,052	--	5,503	--	775,028
Glazes, glass, and enamels	2,803	36	--	11,035	--	3,937	--	17,811
Grogs and crudes, refractory	(3)	--	--	189,592	--	572,708	--	[4]762,300
Gypsum products	--	470	40,000	--	--	4,801	--	45,271
High aluminum (minimum 50% Al_2O_3) refractories	20,700	--	--	288,886	--	62,616	--	372,202
Ink	--	--	--	--	--	11,211	--	11,211
Kiln furniture	7,476	--	--	--	--	1,646	--	9,122
Lightweight aggregate:								
Concrete block	--	--	4,320,662	--	--	--	--	4,320,662
Structural concrete	--	--	1,288,310	--	--	--	--	1,288,310
Highway surfacing	--	--	425,837	--	--	--	--	425,837
Other	--	--	145,834	--	--	--	--	145,834

Linoleum	--	--	--	--	--	350	--	350
Medical, pharmaceutical, and cosmetic	--	1,533	--	--	51	2,069	--	3,653
Mortar and cement, refractory	(2)	--	145,744	227,947	(2)	23,410	51,303	448,404
Oil and grease absorbents	14	--	20,000	--	391,176	20	--	411,210
Paint	--	3,570	800	--	2,791	211,302	--	218,463
Paper coating	(2)	(2)	--	--	150	1,584,403	799	1,585,352
Paper filling	(2)	(2)	--	--	(2)	918,740	10,476	929,216
Pelletizing (iron ore)	--	868,947	--	--	--	--	--	868,947
Pelletizing (other)	--	--	--	24,076	--	--	--	24,076
Pesticides and related products	(2)	3,606	15,000	--	205,019	33,631	--	[4]257,256
Pet absorbent	--	35,416	(2)	--	422,310	(2)	66,298	524,019
Plastics	--	--	(2)	--	(2)	61,721	847	62,568
Plug, tap and wad	--	237	--	4,621	--	--	--	4,858
Pottery	261,252	--	150,032	26,001	--	41,772	--	479,057
Roofing granules	--	--	40,944	--	--	33,403	--	74,347
Rubber	(2)	--	--	--	5	303,619	--	[4]308,624
Sanitary ware	78,373	--	--	--	--	81,851	--	160,224
Sewer pipe, vitrified	465	--	1,154,961	44,075	62	--	--	1,199,563
Tamping dummies	--	--	7,280	--	--	--	--	7,280
Textiles	--	--	--	--	--	1,480	--	1,480
Tile:								
Drain	--	--	436,561	--	--	--	--	436,561
Floor and wall	91,388	477	123,675	9,809	--	11,658	--	237,007
Quarry	992	--	143,642	--	--	--	--	144,634
Roofing	--	15,470	69,703	--	--	(2)	--	[4]85,173
Structural	--	--	111,544	--	--	--	--	111,544
Terra cotta	--	--	22,408	1,100	--	--	--	23,508
Other	2,820	32,977	--	300	8,509	1,200	--	45,806
Waterproofing and sealing	(2)	65,791	--	--	(2)	197	6,028	72,016
Miscellaneous[5]	15,750	10,492	420	8,818	6,050	138,279	--	202,694
Undistributed	121,231	8,132	75,774	36,768	6,623	59,240	--	(6)
Exports	106,813	498,498	127,559	20,420	95,062	922,094	--	1,770,446
Total	800,871	3,520,381	37,579,632	3,352,250	1,341,582	6,127,760	(6)	52,722,476

[1]Total of clays indicated by footnote 2.
[2]Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[3]Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous."
[4]Incomplete total; remainder included with "Miscellaneous."
[5]Includes graphite anodes; mineral wool and insulation; unknown uses; and data indicated by footnote 3.
[6]Included with total for each specific use.

Table 21.—Shipments of principal structural clay products in the United States

Products	1972	1973	1974	1975	1976
Unglazed common and face brick:					
Quantity million standard brick	8,402	8,674	6,673	5,854	6,973
Value million dollars	$404	$451	$376	$358	$461
Unglazed structural tile:					
Quantity thousand short tons	101	94	100	88	71
Value million dollars	$3	$4	$4	$4	$3
Vitrified clay and sewer pipe fittings:					
Quantity thousand short tons	1,718	1,647	1,454	1,190	1,099
Value million dollars	$143	$138	$134	$124	$123
Unglazed, salt glazed, and ceramic glazed structural facing tile, including glazed brick:					
Quantity million equivalent	131	122	97	79	62
Value million dollars	$13	$13	$13	$11	$10
Clay floor and wall tile, including quarry tile:					
Quantity million square feet	308	301	273	236	259
Value million dollars	$159	$168	$168	$159	$186
Total value[1] do	$722	$773	$695	$656	$784

[1]Data may not add to totals shown because of independent rounding.

Table 22.—Common clay and shale used in building brick production in the United States in 1976, by State

State	Short tons	Value	State	Short tons	Value
Alabama	733,119	$1,005,810	Nebraska	100,455	$240,328
Arizona, Hawaii, Idaho	56,006	87,581	New Jersey	50,000	250,000
Arkansas	545,498	642,023	New Mexico and North Dakota	67,112	99,259
California	481,972	973,376	New York	166,122	318,728
Colorado	424,112	1,528,198	North Carolina	2,184,234	3,709,214
Connecticut	124,148	410,055	Ohio	1,353,258	3,227,229
Delaware	11,241	7,869	Oklahoma	530,541	622,973
Florida	2,863	4,295	Oregon	52,092	107,520
Georgia	1,616,490	2,898,541	Pennsylvania	1,020,890	3,097,686
Illinois	328,788	916,278	South Carolina	1,262,287	2,590,768
Indiana	468,238	804,747	South Dakota	12,163	17,474
Iowa and Maine	250,718	409,380	Tennessee	580,444	814,273
Kansas	376,368	715,367	Texas	1,357,614	2,945,834
Kentucky	295,246	410,145	Utah and West Virginia	215,746	406,936
Louisiana	172,041	318,406	Virginia	754,228	1,048,382
Maryland and Michigan	362,344	1,127,915	Washington	243,353	609,188
Massachusetts and Minnesota	132,306	237,858	Wisconsin	2,640	4,858
Mississippi	910,504	1,794,656	Wyoming	52,109	201,820
Missouri	198,622	532,672	Total	17,534,398	35,216,985
Montana and New Hampshire	38,486	79,343			

Table 23.—Clay and shale used in lightweight aggregate production in the United States in 1976, by State and kind

State	Short tons					Total value
	Concrete block	Structural concrete	Highway surfacing	Other	Total	
Alabama and Arkansas	698,286	152,231	28,660	--	879,177	$1,079,432
California	202,496	134,075	--	80,364	416,935	1,191,473
Colorado, Florida, Georgia	194,455	49,636	--	--	244,091	1,044,909
Illinois, Indiana, Iowa	695,719	234,900	3,625	--	934,244	1,844,150
Kansas, Kentucky, Louisiana	337,070	85,798	75,809	20,299	518,976	1,039,179
Maryland, Massachusetts, Minnesota	482,968	21,977	--	26,186	531,131	1,036,037
Mississippi	166,619	14,053	20,075	--	200,747	301,122
Missouri, Nebraska, North Carolina	190,200	126,800	--	--	317,000	491,350
Montana	14,000	--	--	--	14,000	23,000
New York	193,287	95,041	--	--	288,328	1,461,703
North Dakota, Ohio, Pennsylvania	115,300	8,842	--	400	124,542	259,246
Oklahoma	121,233	81,818	--	--	203,051	375,645
Oregon	11,160	7,440	--	--	18,600	42,966
South Dakota, Utah, Washington	144,377	39,342	--	--	183,719	368,935
Tennessee	232,650	3,300	--	--	235,950	553,410
Texas	421,802	231,202	297,668	13,752	964,424	1,599,354
Virginia	99,040	1,855	--	4,833	105,728	158,593
Total	4,320,662	1,288,310	425,837	145,834	6,180,643	12,870,504

Table 24.—Shipments of refractories in the United States, by kind

Product	Unit of quantity	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
CLAY REFRACTORIES					
Superduty fire clay brick and shapes	1,000 9-inch equivalent	63,945	$37,732	57,053	$36,342
Other fire clay, including semisilica, brick and shapes, glasshouse pots, tank blocks, feeder parts, and upper structure parts used only for glass tanks.	do	201,667	72,521	184,879	74,306
High-alumina (50% to 60% Al_2O_3) brick and shapes made of calcined diaspore or bauxite.[1]	do	70,683	78,152	63,337	78,588
Insulating firebrick and shapes	do	56,662	26,658	51,787	27,189
Ladle brick	do	174,580	36,311	197,075	43,668
Sleeves, nozzles, runner brick, and tuyeres.	do	36,048	19,858	36,209	21,837
Hot-top refractories	Short tons	19,132	2,167	22,940	2,645
Kiln furniture, radiant heater elements, potter's supplies, and other miscellaneous-shaped refractory items.	do	NA	13,784	NA	15,659
Refractory bonding mortars	do	105,126	18,646	88,645	17,425
Plastic refractories and ramming mixes, containing up to 87.5% Al_2O_3.[2]	do	200,155	33,042	238,917	47,632
Castable refractories	do	263,103	51,294	267,699	57,708
Gunning mixes	do	20,995	3,652	57,865	10,159
Other clay refractory materials sold in lump or ground form.[3] [4]	do	340,572	16,062	282,867	15,313
Total clay refractories		XX	409,879	XX	448,471
NONCLAY REFRACTORIES					
Silica brick and shapes	1,000 9-inch equivalent	37,478	29,376	38,669	35,721
Magnesite and magnesite-chrome brick and shapes.	do	79,245	152,060	85,106	187,135
Chrome and chrome magnesite brick and shapes.	do	13,890	25,148	13,428	29,455
Shaped refractories containing natural graphite.	Short tons	19,196	21,752	19,852	24,236
Other carbon refractories: Forsterite, pyrophyllite, dolomite, dolomite-magnesite, molten-cast,[5] and other brick and shapes.	1,000 9-inch equivalent	21,759	64,710	28,582	84,159
Other mullite, kyanite, sillimanite, or andalusite brick and shapes.	do	4,273	12,642	3,716	12,356
Other extra-high (over 60%) alumina brick and fused bauxite, fused alumina, and dense-sintered alumina shapes.[6]	do	3,738	20,142	4,205	23,797
Silicon carbide brick, shape, and kiln furniture.	do	4,522	24,975	4,639	27,975
Zircon and zirconia brick and shapes	do	2,121	16,736	1,828	13,287
Refractory bonding mortar	Short tons	37,190	9,182	26,994	8,551
Hydraulic-setting nonclay refractory castables.	do	40,071	16,329	45,869	19,836
Plastic refractories and ramming mixes.	do	171,648	43,732	172,510	50,085
Gunning mixes	do	311,366	53,510	325,160	62,237
Dead-burned magnesia or magnesite.[3] [7]	do	551,108	85,211	526,542	78,137
Other nonclay refractory material sold in lump or ground form.[3]	do	432,265	20,359	491,326	25,661
Total nonclay refractories		XX	595,864	XX	682,628
Grand total refractories		XX	1,005,743	XX	1,131,099

NA Not available. XX Not applicable.

[1]Heated short of fusion; volatile materials thus being driven off in the presence of chemical changes, giving more stable material for refractory use.

[2]More or less plastic brick and materials which, after the addition of any water needed, are rammed into place.

[3]Materials for domestic use as finished refractories, and all exported material.

[4]Including calcined clay, ground brick, and siliceous and other gunning mixes.

[5]Molten cast refractories are made by fusing refractory oxides and pouring the molten material into molds to form finished shapes.

[6]Completely melted and cooled, then crushed and graded for use in a refractory.

[7]Includes shipments to refractory producers for reprocessing in the manufacture of other refractories.

Table 25.— U.S. exports of clay by country and class in 1976

(Thousand short tons and thousand dollars)

Country	Bentonite		Fire clay		Fuller's earth		Kaolin		Ball clay		Clays, n.e.c.		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	(1)	242	(1)	7	(1)	1	11	1,053	--	--	5	450	16	1,753
Australia	34	1,352	6	359	1	36	17	962	--	--	8	706	66	3,415
Austria	(1)	13	--	--	--	--	7	612	--	--	3	298	10	923
Belgium-Luxembourg	(1)	63	(1)	55	1	40	3	234	--	--	2	181	6	573
Brazil	9	643	2	103	(1)	26	10	926	1	26	10	1,003	32	2,727
Canada	397	11,927	98	2,736	9	408	155	6,687	86	2,015	111	4,793	856	28,566
Colombia	3	333	1	47	(1)	1	2	111	--	--	2	194	8	686
Finland	6	184	--	--	--	--	(1)	83	--	--	(1)	49	6	316
France	4	763	1	113	1	110	10	863	--	--	16	1,325	32	3,174
Germany, West	73	3,519	45	2,701	2	131	89	6,489	(1)	9	29	2,166	238	15,015
Guatemala	2	415	(1)	5	1	91	2	144	(1)	2	1	46	6	703
Hong Kong	1	30	1	43	--	--	2	140	--	--	3	111	7	324
Italy	7	302	26	1,787	1	123	135	9,110	(1)	1	5	533	174	11,856
Japan	80	17,202	16	1,265	(1)	33	253	19,925	1	49	56	4,067	406	42,541
Korea, Republic of	(1)	133	1	45	--	--	9	960	(1)	6	2	226	12	1,370
Mexico	2	217	66	1,779	(1)	2	41	2,507	64	1,249	11	404	184	6,158
Netherlands	24	1,047	1	100	8	318	16	957	(1)	1	50	4,030	99	6,453
Philippines	3	399	1	59	--	--	2	119	2	62	4	403	12	1,042
Saudi Arabia	18	881	--	--	(1)	5	--	--	--	--	(1)	5	18	891
Singapore	13	947	(1)	2	1	52	(1)	28	--	--	(1)	3	14	1,032
South Africa, Republic of	3	553	(1)	11	(1)	96	6	757	(1)	10	6	349	15	1,776
Spain	1	98	6	418	(1)	44	6	462	--	--	2	217	15	1,239
Sweden	(1)	92	7	417	--	--	5	341	--	--	4	290	16	1,140
Taiwan	3	267	6	222	--	--	5	447	--	--	15	963	29	1,899
United Arab Emirates	9	866	--	--	2	228	(1)	8	--	--	--	--	11	1,102
United Kingdom	48	2,972	11	443	14	711	8	531	(1)	4	5	459	86	5,120
Venezuela	22	1,240	1	60	(1)	2	23	1,492	1	31	5	279	52	3,104
Other	25	3,702	(1)	118	1	250	22	1,701	2	110	11	1,174	61	7,055
Total	787	50,402	296	12,895	42	2,708	839	57,649	157	3,575	366	24,724	2,487	151,953

[1] Less than 1/2 unit.

Table 26.—U.S. imports for consumption of clay in 1976

Kind	Quantity (short tons)	Value (thousands)
China clay or kaolin, whether or not beneficiated:		
Algeria	1	$1
Canada	524	39
Chile	4	(1)
Germany, West	2	1
Japan	4	2
United Kingdom	22,571	793
Total	23,106	836
Fuller's earth, not beneficiated: United Kingdom	22	2
Bentonite:		
Canada	21	1
Germany, West	13	3
Hong Kong	6	(1)
Italy	56	6
Total	96	10
Common blue and other ball clay: Not beneficiated: United Kingdom	8,630	242
Common blue and other ball clay: Wholly or partly beneficiated: United Kingdom	2,014	100
Clays, n.e.c., not beneficiated:		
Argentina	457	16
Canada	34	1
Total	491	17
Clays, n.e.c., wholly or partly beneficiated:		
Canada	8	1
Italy	50	7
Germany, West	157	22
Japan	10	1
Spain	27	1
United Kingdom	1,208	119
Total	1,460	151
Clays artificially activated with acid:		
Canada	930	62
France	1	2
Germany, West	58	28
Japan	821	258
Mexico	1,039	104
Philippines	(1)	1
United Kingdom	(1)	1
Total	2,849	456
Grand total	38,668	1,814

[1]Less than 1/2 unit.

WORLD REVIEW

Australia.—The Dressler Ceramic Group of Pulman-Swindell, a division of Pullman, Inc., Pittsburgh, Pa., received a $1.1 million contract from Cragie Clays Pty. Ltd. of Longford, Tasmania. Cragie Clays is a division of Clifton Brick Ltd. The contract covers a tunnel kiln, dryer, and related facilities to manufacture bricks.[8] Another contract was awarded to the same group by Brick and Pipe Industries Ltd. of Melbourne, Australia. This contract covered design, engineering, and construction of a tunnel kiln, dryer, and associated facilities.[9] A consortium of Consolidated Gold Fields Australia, Western Titanium Ltd., and Winjallock Resources Ltd. formed Western Australian Kaolin Co. to exploit high-grade

[8]Iron Age. Industry Briefs—Contracts. V. 218, No. 14, Oct. 4, 1976, p. 27.
[9]Iron Age. Industry Briefs-Contracts. V. 218, No. 23, Dec. 6, 1976, p. 23.

kaolin reserves near Gabbin, about 200 miles northeast of Perth, in Western Australia.[10]

Bolivia.—Plans were announced for a bentonite beneficiation plant near Oruro on the Altiplano, to come onstream in early 1977. The new plant was to be built by the Baroid Div. of NL Industries, Inc., in a joint venture with the local Mosamar Co. Deposits of kaolin were also found on the Altiplano as well as in the east, near Santa Cruz.[11]

Brazil.—Laporte Industries Ltd. (United Kingdom) acquired a 40% participation in the major domestic bentonite manufacturer Bentonite Uniao Group (BUN), for an estimated $3 million.[12] Caulim Da Amazonia Ltda. scheduled startup of its 350,000-ton-per-year kaolin operation at Monte Dourado, Munguba, for May of 1977. The beneficiation plant's 220,000-ton-per-year capacity was targeted for the paper industry.[13]

In another kaolin operation, J. M. Huber Corp. and Construtora Mendes Junior S.A. were constructing a kaolin slurry plant to exploit deposits located on the Rio Capim, in the State of Pará.[14]

Burundi.—An open pit kaolin mining operation was being set up in the Kayanza region. The entire 3,000 tons scheduled for production annually was to be used as an inert carrier for domestically produced pesticides.[15]

Canada.—English China Clay Ltd. (ECC) completed a new slurry facility for its imported kaolin at Three Rivers, Quebec.[16]

Guyana.—The Government of Guyana's 16,000-ton-per-year airfloat plant was expanded to about 40,000 tons. The plant, located at San Isidrio in the State of Bolivar, about 225 miles southeast of Porto Ordaz, processes a sandy primary kaolin by a novel dry technique.[17]

India.—Maharaja Cassimbajar China Clay Mines Pvt. Ltd. was in the process of doubling the crude output of its kaolin clay operation in the Singbhum, Bihar area, to 80,000 tons per year. Production of refined levigated kaolin was similarly doubled from 9,000 to 18,000 tons per year. The clay is consumed domestically by paper (30%), ceramics (30%), and textiles (15%), as well as the rubber, refractories, and paint industries.[18]

Iran.—A $2.5 million contract was signed with the Industrial Equipment Div. of F. L. Smidth & Co. and the Danish Leca Co. to supply a complete lightweight expanded clay aggregate plant. Delivery was set for early 1977, and on completion the plant will be the first lightweight aggregate facility in the Middle East.[19]

Mexico.—Construction of a new plant near Puebla for manufacturing split and ornamental tile and glazed and unglazed brick was announced by Industrial Texmelucan Co. The new plant's rated capacity was to be around 230 tons per day.[20]

Philippines.—Filmag Philippines Inc.'s 40,000-ton-per-year bentonite and processing plant at Merida, northwestern Leyte, was to begin operations at yearend. Most of the output was scheduled for export.[21]

South Africa, Republic of.—The bentonite, open pit mine operated by Pratley Perlite Mining Co. Pty. Ltd. at Nxwala, Zululand, was to be onstream at yearend. A beneficiation plant at Krugersdorp was currently under construction.[22]

Turkey.—The reserves of nonmetallic minerals of Eskisehir Province were reported to include over 500,000 tons of kaolin.[23]

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[10] Iannicelli, J. Kaolin—Modest Recovery, Higher Prices in 1976. Eng. Min. J., v. 178, No. 3, March 1977, pp. 139-140.
[11] U.S. Embassy, La Paz, Bolivia. State Department Airgram A-86, Aug. 2, 1976, pp. 63-65.
[12] European Chemical News. ECN Market Report—In Brief. V. 28, No. 738, May 28, 1976, p. 12.
[13] Industrial Minerals (London). Company News and Mineral Notes. No. 103, April 1976, p. 66.
[14] Work cited in footnote 10.
[15] Industrial Minerals (London). Company News and Mineral Notes. No. 110, November 1976, p. 42.
[16] Work cited in footnote 10.
[17] Work cited in footnote 10.
[18] Industrial Minerals (London). No. 107, August 1976, p. 10.
[19] Rock Products. Rock Newscope. V. 79, No. 8, August 1976, p. 18.
[20] American Ceramic Society Bulletin. Newsnotes—Mexican Tile Plant Announced. V. 55, No. 9, September 1976, p. 824.
[21] Industrial Minerals (London). No. 108, September 1976, p. 53.
[22] Work cited in footnote 13.
[23] Industrial Minerals (London). No. 109, October 1976, p. 55.

Table 27.—Kaolin: World production, by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
North America:			
Mexico	103	133	79
United States[2]	6,393	5,334	6,115
South America:			
Argentina	103	104	[e]105
Brazil (beneficiated)	191	191	[e]191
Chile	83	66	74
Colombia[e]	115	[r]138	165
Ecuador	1	3	[e]3
Paraguay	13	13	[e]15
Peru	[r e]3	[r e]6	15
Venezuela	19	17	11
Europe:			
Austria (marketable)	90	83	[e]79
Belgium[e]	110	110	110
Bulgaria[e]	165	165	165
Czechoslovakia	534	580	601
Denmark[e]	20	20	20
France[3]	397	336	331
Germany, West (marketable)	546	462	409
Greece	91	80	78
Hungary	81	98	95
Italy:			
Crude	99	86	90
Kaolinitic earth	25	31	29
Poland	[r]94	92	104
Portugal	55	57	56
Romania[e]	96	96	100
Spain (marketable)[4]	223	229	218
U.S.S.R.[e]	2,300	2,400	2,400
United Kingdom	3,858	3,549	[e]3,500
Africa:			
Algeria[e]	10	12	12
Angola	([5])	([6])	--
Egypt	28	[e]30	31
Ethiopia (including Eritrea)	[r e]44	55	[e]55
Kenya	([5])	([5])	--
Malagasy Republic	4	5	28
Mozambique	4	2	[e]2
South Africa, Republic of	54	63	66
Swaziland	2	3	1
Tanzania	1	1	[e]1
Asia:			
Bangladesh	1	4	[e]4
Hong Kong	4	2	1
India:			
Salable	311	259	328
Processed	116	104	108
Indonesia	29	28	[e]28
Iran	[e]110	[e]110	140
Israel	5	13	11
Japan	456	227	249
Korea, Republic of	300	329	518
Malaysia	161	19	29
Pakistan	[r]1	2	1
Sri Lanka	6	4	5
Taiwan[e 7]	23	23	23
Thailand	[e]22	17	18
Turkey	28	38	72
Oceania:			
Australia	108	[e]110	[e]110
New Zealand	18	30	30
Total	[r]17,654	15,969	17,029

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, the People's Republic of China, East Germany, Lebanon, Nigeria, Vietnam, Southern Rhodesia and Yugoslavia also produced kaolin, but information is inadequate to make reliable estimates of output levels. Costa Rica, Guatemala, Morocco, and Mozambique each produced less than 500 tons in each of the years covered by this table.

[2]Kaolin sold or used by producers.

[3]Includes kaolinitic clay.

[4]Excludes unwashed kaolin as follows in thousand short tons: 1974—84; 1975—187; 1976—150 (estimated).

[5]Revised to zero.

[6]Less than 1/2 unit.

[7]Data given are for ceramic and pottery clays.

Table 28.—Bentonite: World production, by country

(Short tons)

Country[1]	1974	1975	1976[p]
North America:			
Guatemala	2	[e]10	[e]10
Mexico	67,445	35,833	61,270
United States	3,310,500	3,229,267	3,979,117
South America:			
Argentina	124,806	127,870	[e]127,000
Brazil	85,008	128,733	[e]132,000
Colombia	1,100	[e]1,100	[e]1,100
Peru	[r] [e]11,000	[r] [e]28,000	43,591
Europe:			
France[e]	15,400	15,400	15,400
Greece	423,737	[r] [e]386,000	345,538
Hungary	[e]80,000	96,890	78,427
Italy	379,089	308,691	258,648
Poland[e]	55,000	55,000	55,000
Romania[e]	69,200	[r]69,200	70,000
Spain	83,684	83,060	[e]83,000
Africa:			
Algeria (bentonite clay)[e]	[r]33,000	[r]39,000	43,000
Morocco	3,652	3,363	[e]3,300
Mozambique[e]	4,400	2,000	2,000
South Africa, Republic of	41,671	41,391	43,654
Asia:			
Burma	560	1,008	1,053
Cyprus (bentonite clay)[2]	[r]4,979	12,690	3,123
Iran	[r]55,000	55,000	[e]55,000
Israel (metabentonite)	4,190	3,300	17,000
Japan	498,314	444,965	[e]440,000
Pakistan	1,010	1,015	720
Philippines	--	729	2,334
Turkey	14,793	43,832	44,000
Oceania:			
Australia[3]	885	([4])	--
New Zealand (processed)	1,206	[5]5,783	1,149
Total	[r]5,369,631	5,219,130	5,906,434

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, Austria, Canada, the People's Republic of China, West Germany, and the U.S.S.R. are believed to have produced bentonite, but output is not reported and available information is inadequate to make reliable estimates of output levels.

[2]Exports.

[3]Including bentonite clay.

[4]Revised to zero.

[5]Includes unprocessed bentonite.

Table 29.—Fuller's earth: World production, by country[1]

(Short tons)

Country[2]	1974	1975	1976[p]
Algeria	24,251	[r] [e]24,300	[e]24,300
Argentina	238	260	[e]275
Australia	86	[e]90	[e]90
Italy	116,073	77,700	27,402
Mexico	59,372	42,105	22,165
Morocco (smectite)	22,150	26,147	40,530
Pakistan	17,216	12,775	[e]21,000
Senegal (attapulgite)	10,774	18,407	5,100
United Kingdom	182,980	180,779	[e]175,000
United States	1,224,640	1,189,064	1,341,582
Total	[r]1,657,780	1,571,627	1,657,444

[e]Estimate. [p]Preliminary. [r]Revised.

[1]Excludes centrally planned economy countries, some of which presumably produce fuller's earth, but for which no information is available.

[2]In addition to the countries listed, France, Iran, Japan, and Turkey have reportedly produced fuller's earth in the past and may continue to do so, but output is not reported, and available information is inadequate to make reliable estimates of output levels.

United Kingdom.—In the past year, ECC has emphasized developing distribution and storage systems (see Canada) and exploitation of overseas deposits. Significant reserves of kaolin have been found in France and acquired with French partners.[24] ECC started up an 84-inch high gradient wet magnetic separator (HGMS) in Cornwall during June and planned to take delivery of a second unit in 1977.[25] These units, similar to the four now operating in Georgia, are used to extract mica and other feebly magnetic contaminants from kaolin. Hemerdon Mining and Smelting Ltd. completed initial exploration drilling on a china clay-tin-tungsten prospect on the edge of the Dartmoor, 7 miles from Plymouth in Devon. Assay results from these holes were unannounced, but further drilling was contemplated.[26] In clay deliveries ECC has chosen a system of flexible intermediate bulk containers termed "MiniBULK."[27] These containers, in suitable ships, could reduce shipment costs by 30%, and waste through damaged sacks to zero.

Yugoslavia.—The bentonite facility at Kriva Polanka, Serbia, was to be augmented with a new 20,000-ton-per-year soda ash-treated bentonite plant. The new plant, costing about $5 million, will boost total production to 40,000 tons. The soda ash-treated bentonite was intended for foundry application.[28]

TECHNOLOGY

The Federal Bureau of Mines and nine companies (one less than in 1975) eight aluminum producers and a refractory manufacturer continued cosponsoring research on extracting alumina from domestic materials that are plentiful which could ease our dependence on imported metallurgical- and refractory-grade bauxite. Using miniplant facilities at the Boulder City (Nev.) Metallurgy Laboratory, and with support from the eight other Bureau Research Centers, researchers were investigating several methods for extracting alumina from clays, anorthosite, alunite, and dawsonite-bearing oil shales. Each participating company was contributing $50,000 annually, with the cost to the Bureau in excess of $500,000 annually.

The clay-nitric acid miniplant, the first acid process studied, using calcined kaolin was successfully completed and placed on a standby basis. The miniplant study showed that with four stages of countercurrent decantation (CCD), over 90% of the alumina was recoverable. Current work was being devoted to the design, construction, and operation of a kaolin clay-hydrochloric acid miniplant. This miniplant has already been operated for two continuous campaigns of the leaching, solvent extraction, and solids-liquid separation sections mainly to optimize alumina recovery from the leach solutions. Preliminary data show that recoveries of over 95% of the acid-soluble alumina during leaching is possible with a CCD circuit.

A complex problem of $AlCl_3.6H_2O$ crystallization in the circulating pump was solved by a redesigned pump, that eliminated salt supersaturation. Another problem area, thermal decomposition of the salt to alumina in the miniplant, was studied in an indirectly heated rotary calciner and a silicon carbide-heated rotary calciner. These simulated studies have achieved over 90% decomposition of the salt with a residual Cl- of about 0.05%.

Miniplant support studies were in the areas of determining the best materials for construction (emphasizing corrosion), analytical methods for low levels of solvent extraction reagents in purified leach liquors and methods for removal, and tests on the sulfurous acid leaching of clays, lime sinter processing of anorthosites, alternate decomposition methods for aluminum chloride, and disposal of processing wastes. Of particular interest are the latter four studies and the two contracts awarded.

Tests on the sulfurous acid leaching of a calcined kaolin showed that long leaching times (up to 20 hours), using a 30% SO_2 solution, at moderate temperatures and pressures leached up to 80% of the alumina. Best results on recovering alumina from a lime-anorthosite "dusted" sinter was nearly 90%. This research also revealed that up to 1% carbon was beneficial in promoting dusting. Promising results on alternate $AlCl_3.6H_2O$ decomposition were shown by fluidized bed decomposition, 92% at below 200° C, and by a two-stage decomposition system using a flowing airstream approach.

[24]Industrial Minerals (London). World of Minerals—ECC Prospering in a Poor Year. No. 102, March 1976, pp. 11-12.

[25]Work cited in footnote 10.

[26]Mining Journal (London). Industry in Action: Exploration—Work at Hemerdon. V. 287, No. 7376, Dec. 31, 1976, p. 525.

[27]Industrial Minerals (London). No. 111, December 1976, p. 64.

[28]Industrial Minerals (London). No. 106, July 1976, p. 51.

The fluidized bed temperature of under 200° C should make selection of construction material easier. The two-stage system produced an alumina product containing less than 0.004% residual Cl-. Disposal of the processing wastes dealt with the silica wastes from the clay-HCl process. Dewatering techniques, vacuum filtration, and addition of polyethylene oxides were currently being pursued with some success. One contract awarded was for delineating the environmental factors involved in recovering alumina from domestic ores.[29] The other contract was for process feasibility and preliminary pilot plant design, and a more detailed evaluation of the clay-HCl and clay-HNO_3 processes.[30]

In other clay work, the Bureau continued to aid State Geological Surveys and other Federal agencies in delineating undeveloped deposits of ceramic raw materials by clay testing and evaluation, and devising flowsheets designed to upgrade marginal materials. A cooperative program evaluated Montana swelling bentonites for their use in drilling fluids, foundry sands, and pelletizing taconites.

Other alternative methods of producing alumina from clays were patented during the year. In one patent, the dehydrated clay or other relatively low-grade aluminiferous material is reacted with molten anhydrous magnesium chloride at about 2,000° C in a magnesia particulate fluidized bed to vaporize aluminum trichloride.[31] The vapor is separated from the entrained magnesia and used either in producing aluminum metal or chemicals. The byproduct is suitable for refractory manufacture. Another patent outlines a sulfuric acid method for recovering the alumina from clays or kyanite.[32] This technique first forms a concentrated acid-clay slurry which is then heated to a hard anhydrous mass containing aluminum sulfate and silica. The mass is then reduced to an alkali-soluble alumina form and subsequently leached and calcined to recover an alumina product. In a second acid-leaching patent, the clay is fed into the top of a leaching tower and hydrochloric acid flowed countercurrently to leach $AlCl_3$ from the descending ore.[33] Values are crystallized from the leach solution and passed through a crystallizer-washer-thermal decomposer to recover $Al(OH)_3$ suitable for calcining to pure alumina.

The details of producing alumina from coal shales and kaolinitic clays by the H+ process was published.[34] This work included not only the flowsheets for these two types of ore but also a general discussion on bauxite reserves, resources, and rates of consumption. The energy consumption in different nonbauxitic processes was also compared with the Bayer process. A brief article was published on the production of alumina from the U.S.S.R. nonbauxitic sources.[35] In producing alumina from nepheline, the complete processing cycle also yields soda, potash, portland cement, and metallic gallium.

A three-part treatise covered ball and plastic clays. The first part dealt with differing ball clay properties required in ceramics-sanitary ware, wall tiles, earthenware, electrical porcelain, stoneware, refractories, and filler-extenders.[36] This portion also discussed production in the United Kingdom, the companies, and mining and processing. A brief mention was also made of the American and other European producers. The second part detailed the materials and manufacturing of pottery and whiteware.[37] This part, again with English

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[29] Colorado School of Mines Research Institute (Goldon, Colo.) and PEDCO Environmental, Inc. (Cincinnati, Ohio). Evaluation of the Environmental Factors Involved in Metallurgical Processes to Utilize Domestic Resources for Production of Alumina. BuMines Contract J0275040, Oct. 1, 1977; available for consultation in Division of Metallurgy, Washington, D.C.

[30] Kaiser Engineers, Division of Raymond International, Inc. (Oakland, Calif.). Alumina Process Feasibility Study and Preliminary Pilot Plant Design. BuMines Contract J0265048, Oct. 1, 1976; available for consultation in Division of Metallurgy, Washington, D.C.

[31] Fougner, S. Production of Aluminum Trichloride and Magnesium Oxide. U.S. Pat. 3,939,247, Feb. 17, 1976.

[32] Lowenstein, H. M., and A. M. Lowenstein. Alumina Production. U.S. Pat. 3,983,212, Sept. 28, 1976.

[33] Messner, G. Method for Fabrication of Pure Alumina from Al_2O_3 and Silica Containing Raw Materials by Leaching with Hydrochloric Acid. U.S. Pat. 3,959,438, May 25, 1976.

[34] Cohen, J., and H. Mercier. Recovery of Alumina from Non-Bauxite Aluminum-Bearing Raw Materials. Ch. in Light Metals, American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., New York, v. 2, 1976, pp. 3-18.

[35] Engineering and Mining Journal. This Month in Mining—Soviet Alternatives for Alumina Production Said to be Cheap, Clean, Easy. V. 177, No. 6, June 1976, p. 35.

[36] Pages 15-28 of work cited in footnote 18.

[37] Pages 19-35 of work cited in footnote 27.

examples, discussed body preparation, plastic and nonplastic shaping techniques, drying and firing, and glazes for manufacturing bone china, porcelain, and vitreous china. The third part concerned the raw materials and the United Kingdom pottery and whiteware industry.[38] The use of linear programing to formulate whitewares from a variety of raw materials at minimum cost, while ensuring that product composition remained within specified limits, was described.[39] Forming a product from cheaper substitute raw materials, as opposed to more expensive traditional raw materials, was cited as a practical problem.

The genesis and geology of the Brazilian Felipe kaolin deposits, their mining, and beneficiation for the world paper markets was outlined in a brief work.[40] A European forecast for kaolin and paper based on the technology of filling and coating printing and writing paper was related to economic factors and future international kaolin supplies.[41] A brief article reviewed the magnetic separation of kaolin clays.[42] This high-intensity, HGMS method permits the mining of lower-grade crude kaolin and reduces the consumption of leaching chemicals. The kaolin surface modification techniques—chemical bonding, chemisorbtion, and coating—for this hydrophilic mineral for eventual use in organics such as rubber, nylon, and polypropylene was summarized.[43]

The mining, processing, laboratory, and pilot plant capabilities of selected French clay and chamotte (calcined clays) producers for use in refractories, ceramics, and filler-extender products was briefly reviewed.[44] A three-section article on industrial minerals in Spain included its bentonite, sepiolite, and attapulgite deposits.[45] The first section touches on the geology of the country, with particular reference to industrial minerals. The second section summarizes, with tables, Spanish production and trade in these minerals. In the final section, some of the more important Spanish producers, both large and small, are reviewed with emphasis on their products, production capabilities, and processing generalities.

The phosphate adsorption capacities of three clays—kaolinite, montmorillonite, and illite—were studied at different pH and ionic strengths.[46] The study showed that kaolin and illite, during periods of high runoff and under slightly acidic pH, contain high amounts of phosphate-bound particles. In transport of these clays, however, if leading to a basic environment, the release of the particles would occur. For clays high in calcium, such as montmorillonite, the reverse response to pH was noted. The free metal content of the clay (in particular Fe and Ca) was shown to be of greater importance in phosphate adsorption than the previously thought alumina-to-silica ratio under varying pH conditions. Another research work evaluated the attenuation properties of several clay minerals, a kaolin, a swelling bentonite, and an illite, to determine whether they would be suitable for sanitary land fill liners to prevent or mitigate pollution of ground and surface waters by leachates from municipal solid waste.[47] Swelling bentonites had the highest attenuation capability, followed by illite, and then kaolin. A similar work considered the effect of pH on the ability of clays to attenuate lead.[48] This work, as with the other two, also investigated the mechanisms responsible for attenuation.

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[38]Pages 37-49 of work cited in footnote 27.

[39]Pandya, D. V., and S. K. Roy. Formulation of Whitewares by Linear Programing. Am. Ceramic Soc. Bull., v. 55, No. 8, August 1976, pp. 711-714.

[40]Pages 33-35 of work cited in footnote 18.

[41]Pages 37-43 of work cited in footnote 21.

[42]Engineering and Mining Journal. Magnetic Separators Find Wider Use. V. 177, No. 6, p. 231.

[43]Helmer, B. M., P. I. Prescott, and P. Sennett. Surface-Modified Kaolin in Plastic. Proc. Ann. Conf., Reinforced Plastics/Composites Institute, Washington, D.C., Feb. 3-6, 1976. Society of the Plastics Industry, New York, v. 31, 1976, sec. 8-G, pp. 1-8.

[44]Pages 43-46 of work cited in footnote 28.

[45]Industrial Minerals (London). The Industrial Minerals of Spain. No. 103, April 1976, pp. 15-62.

[46]Edzwald, J. K., D. C. Toensing, and M. C-Y. Leung. Phosphate Adsorption Reactions with Clay Minerals. Environ. Sci. Technol., v. 10, No. 5, May 1976, pp. 485-490.

[47]Griffin, R. A., N. F. Shimp, J. D. Steele, R. R. Ruch, W. A. White, and G. M. Hughes. Attenuation of Pollutants in Municipal Landfill Leachate by Passage Through Clay. Environ. Sci. Technol., v. 10, No. 13, December 1976, pp. 1262-1268.

[48]Griffin, R. A., and N. F. Shimp. Effect of pH on Exchange-Adsorption or Precipitation of Lead from Landfill Leachates by Clay Minerals. Environ. Sci. Technol., v. 10, No. 13, December 1976, pp. 1256-1261.

Coal—Bituminous and Lignite

By Lawrence H. Frey[1]

Bituminous coal and lignite production increased from 648.4 million tons in 1975 to 678.7 million tons in 1976, an increase of 4.7%. The increase occurred primarily as a result of the increased demand for coal by electric utilities. The total value of production in 1976 was $13.2 billion compared with $12.5 billion in 1975.

In 1976, there were 6,161 bituminous coal and lignite mines operating in 26 States in Appalachia, the Midwest, and the Mountain and Pacific regions. The leading coal-producing States in order of output were Kentucky, West Virginia, Pennsylvania, Illinois, Ohio, and Virginia. Combined they accounted for 71% of total U.S. production. Total underground coal production increased 2.1 million tons in 1976; production from surface mines increased 28.2 million tons.

Prices of coal increased only moderately in 1976. The average mine price of bituminous coal and lignite increased from $19.23 per ton in 1975 to $19.43 per ton in 1976. The average price of coal produced at underground mines increased from $26.28 per ton in 1975 to $26.56 per ton in 1976. The average f.o.b. mine price of coal at surface mines increased from $13.43 per ton to $13.96 per ton. The average rail freight charge on coal increased from $5.23 per ton in 1975 to $5.86 per ton in 1976.

There were approximately 12,400 more workers mining bituminous coal and lignite in 1976 compared with the total for 1975. The total number of production workers increased from 189,880 workers to 202,280. The decline in productivity was less in 1976 than in 1975. Productivity at underground mines declined from 9.54 tons per man per day to 9.10 tons per man per day. Productivity at surface mines declined from 26.69 tons per man per day to 26.40 tons per man per day. The average productivity at all mines declined from 14.74 tons per man per day in 1975 to 14.46 tons in 1976.

In 1976, the U.S. exported 59.4 million tons of bituminous coal, a decrease of 6.3 million tons compared with exports in 1975. Japan maintained its position as the principal U.S. foreign market with 32% of total U.S. coal exports. Other major shipments of coal went to Canada and Europe, which accounted for 28% and 33%, respectively.

There was a 25-million-ton increase in coal shipped from western coal-producing States in 1976. Shipments of higher sulfur coals from Midwestern coal-producing States declined 5 million tons. Shipments of coal from the Appalachian coalfields declined by nearly 2 million tons.

Tables 12 through 14 summarize the shipments of coal and lignite in 1976. Table 15 shows the quantitative changes in total tons, by geographic division and State of destination, from 1972 through 1975. These distribution data are based on reports submitted quarterly to the Bureau of Mines, Department of the Interior by producers, sales agents, distributors, and wholesales, who normally produce or sell 50,000 tons or more annually. To account for total industry shipments, estimates for the remaining shipments are included, based on data from the Federal Power Commission (FPC) and other reliable coal statistical reporting agencies.

The annual mine operation survey includes all bituminous coal produced in the United States except production from mines that produce less than 1,000 tons per year. All quantity figures represent net tons of marketable coal and excludes washery and other refuse. Statistics are final and are based upon detailed annual reports of production and mine operation furnished by producers. For production not directly reported (chiefly that of small mines), accurate data was obtained from the records of State mine departments.

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[1]Mineral specialist, Division of Fuels Data.

The weekly and monthly estimates of production, summarized in tables 3 and 4, are based upon railroad carloads of coal reported weekly by railroads, river shipments reported by the U.S. Army Corps of Engineers, reports from mining companies, and monthly production statements compiled by local operators associations and State mine departments.

Table 1.—Salient statistics of the bituminous coal and lignite industry in the United States

Item	1972	1973	1974	1975	1976
Production ---------- thousand short tons	595,386	591,738	603,406	648,438	678,685
Value ---------- thousands	$4,561,983	$5,049,612	$9,502,347	$12,472,486	$13,189,481
Consumption ---------- thousand short tons	r518,348	r556,912	r552,954	r557,535	598,750
Stocks at yearend:					
Industrial consumers and retail yards ---- do	r115,748	r103,412	r95,477	r127,150	133,555
Stocks on upper lake docks ---- do	939	822	1,051	1,185	835
Exports[1] ---- do	55,997	52,870	59,926	65,669	59,406
Imports[1] ---- do	47	127	2,080	940	1,203
Price indicators, average per net ton:					
Cost of coking coal at merchant coke ovens	$17.67	$19.77	$34.20	$52.63	$54.90
Railroad freight charge[2]	$3.67	$3.71	$4.71	$5.23	$5.86
Value f.o.b. mines (sold in open market)	$7.35	$8.06	$15.16	$18.02	NA
Value f.o.b. mines	$7.66	$8.53	$15.75	$19.23	$19.43
Method of mining:					
Hand-loaded underground thousand short tons	2,974	1,970	710	508	NA
Mechanically loaded underground ---- do	301,129	297,384	276,599	292,317	NA
Percentage mechanically loaded	99.0	99.3	99.7	99.8	NA
Percentage cut by machine	37.4	35.8	33.0	32.0	NA
Mined by surface ---- thousand short tons	291,284	292,384	326,097	355,612	383,805
Percentage mined by surface	48.9	49.5	54.0	54.8	56.6
Mechanically cleaned ---- thousand short tons	292,829	288,918	265,150	266,993	NA
Percentage mechanically cleaned	49.2	48.8	43.9	41.2	NA
Number of mines	4,879	4,744	5,247	6,168	6,161
Capacity at 235 days ---- thousand short tons	r633,100	r613,600	r688,400	r656,825	687,475
Average number of men working daily:					
Underground mines	112,252	111,083	119,416	134,710	140,260
Surface mines	37,013	37,038	47,285	55,170	62,020
Total	149,265	148,121	166,701	189,880	202,280
Average number of days worked:					
Underground mines	222	231	205	228	231
Surface mines	217	215	208	241	235
Total	221	227	206	232	232
Production per man per day:					
Underground mines ---- short tons	11.91	11.66	11.31	9.54	9.10
Surface mines ---- do	36.33	36.67	33.16	26.69	26.40
Total ---- do	17.74	17.58	17.58	14.74	14.46

rRevised. NA Not available.
[1]Bureau of the Census, U.S. Department of Commerce.
[2]Interstate Commerce Commission.

Table 2.—Annual average unit heat value of bituminous coal and lignite produced and consumed 1955-76[1]

Year	Production			Domestic consumption		
	Total (thousand short tons)	Heat value (trillion Btu)	Average Btu per pound	Total (thousand short tons)	Heat value (trillion Btu)	Average Btu per pound
1955	464,633	12,080	13,000	423,412	10,940	12,920
1956	500,874	13,013	12,990	432,858	11,142	12,870
1957	492,704	12,800	12,990	413,668	10,640	12,860
1958	410,446	10,663	12,990	366,703	9,366	12,770
1959	412,028	10,581	12,840	366,256	9,332	12,740
1960	415,512	10,662	12,830	380,429	9,693	12,740
1961	402,977	10,308	12,790	374,405	9,502	12,690
1962	422,149	10,782	12,790	387,774	9,826	12,670
1963	458,928	11,712	12,760	409,225	10,353	12,650
1964	486,998	12,418	12,750	431,116	10,899	12,640
1965	512,088	13,017	12,710	459,164	11,580	12,610
1966	533,881	13,507	12,650	486,266	12,205	12,550
1967	552,626	13,904	12,580	480,416	11,981	12,470
1968	545,245	13,664	12,530	498,830	12,401	12,430
1969	560,505	13,957	12,450	507,275	12,509	12,330
1970	602,932	14,820	12,290	515,619	12,488	12,110
1971	552,192	13,385	12,120	494,862	11,857	11,980
1972	595,386	14,319	12,025	516,776	12,273	11,875
1973	591,738	14,208	12,005	556,022	13,150	11,825
1974	603,406	14,320	11,865	552,709	12,750	11,535
1975	648,438	15,044	11,600	556,301	12,684	11,400
1976	678,685	15,712	11,575	598,750	13,622	11,375

[1]Prior to 1955 the average heat content of the annual output of bituminous coal and lignite was measured at 13,100 Btu per pound. This value was based on an estimate made in 1949 (U.S. Bureau of Mines Information Circular 7538). In recent years this heat value has not been representative of the average unit heat value of the total annual coal supply because of the large annual increases in utilization of coal of lower heat values by the electric utility industry. The annual production values shown in this table are weighted averages of known and estimated Btu values of coal shipments to each major consuming sector. They include, for example, the Btu value of coal consumed at electric utility generating plants as reported to the Federal Power Commission. Currently, electric utility plants account for 75% of total domestic coal consumption. The averages for domestic consumption exclude shipments overseas and to Canada, the preponderance of which is high-Btu metallurgical coal, thus accounting for the difference in values between total production and domestic consumption.

Table 3.—Estimated production of bituminous coal and lignite in the United States by week, 1975 and 1976 (final)

(Thousand short tons)

1975				1976			
Week ended—	Production	Maximum number of working days	Average production per working day	Week ended—	Production	Maximum number of working days	Average production per working day
Jan. 4	[1]6,751	[1]3.2	[2]2,110	Jan. 3	[1]2,569	1	2,569
Jan. 11	13,060	6	2,177	Jan. 10	11,914	6	1,986
Jan. 18	11,344	6	1,891	Jan. 17	12,980	6	2,163
Jan. 25	11,959	6	1,993	Jan. 24	12,105	6	2,018
Feb. 1	12,722	6	2,120	Jan. 31	13,000	6	2,167
Feb. 8	12,644	6	2,107	Feb. 7	12,513	6	2,086
Feb. 15	12,751	6	2,125	Feb. 14	13,603	6	2,267
Feb. 22	12,857	6	2,143	Feb. 21	13,493	6	2,249
Mar. 1	13,566	6	2,261	Feb. 28	14,164	6	2,361
Mar. 8	13,133	6	2,189	Mar. 6	12,590	6	2,098
Mar. 15	11,917	6	1,986	Mar. 13	13,582	6	2,264
Mar. 22	12,535	6	2,089	Mar. 20	13,670	6	2,278
Mar. 29	12,155	6	2,026	Mar. 27	13,925	6	2,321
Apr. 5	10,986	5	2,197	Apr. 3	12,346	5	2,469
Apr. 12	12,095	6	2,016	Apr. 10	13,436	6	2,239
Apr. 19	12,950	6	2,158	Apr. 17	13,745	6	2,291
Apr. 26	12,764	6	2,127	Apr. 24	14,150	6	2,358
May 3	12,571	6	2,095	May 1	13,370	6	2,228
May 10	12,900	6	2,150	May 8	14,202	6	2,367
May 17	12,989	6	2,165	May 15	14,044	6	2,341
May 24	13,112	6	2,185	May 22	14,447	6	2,408
May 31	11,514	5	2,303	May 29	14,490	6	2,415
June 7	13,958	6	2,326	June 5	11,725	5	2,345
June 14	13,898	6	2,316	June 12	14,235	6	2,373
June 21	13,721	6	2,287	June 19	14,760	6	2,460
June 28	13,283	6	2,214	June 26	14,236	6	2,373
July 5	6,965	3.0	2,322	July 3	8,332	3.5	2,381
July 12	7,894	3.5	2,255	July 10	6,359	2.7	2,355
July 19	10,814	4.7	2,301	July 17	11,032	4.7	2,347
July 26	11,853	5.2	2,279	July 24	12,233	5	2,447
Aug. 2	12,992	6	2,165	July 31	11,086	4.7	2,359
Aug. 9	13,689	6	2,282	Aug. 7	9,375	4	2,344
Aug. 16	12,824	6	2,137	Aug. 14	9,677	4.1	2,360
Aug. 23	11,969	6	1,995	Aug. 21	14,120	6	2,353
Aug. 30	10,046	6	1,674	Aug. 28	14,895	6	2,483
Sept. 6	9,446	5	1,889	Sept. 4	14,399	6	2,400
Sept. 13	13,526	6	2,254	Sept. 11	12,455	5	2,491
Sept. 20	14,242	6	2,374	Sept. 18	14,465	6	2,411
Sept. 27	13,666	6	2,278	Sept. 25	14,335	6	2,389
Oct. 4	13,551	6	2,259	Oct. 2	13,997	6	2,333
Oct. 11	13,577	6	2,263	Oct. 9	14,065	6	2,344
Oct. 18	13,205	6	2,201	Oct. 16	14,110	6	2,352
Oct. 25	13,352	6	2,225	Oct. 23	14,134	6	2,356
Nov. 1	12,603	6	2,101	Oct. 30	13,128	5.4	2,431
Nov. 8	14,191	6	2,365	Nov. 6	13,710	6	2,285
Nov. 15	13,520	6	2,253	Nov. 13	13,820	6	2,303
Nov. 22	13,836	6	2,306	Nov. 20	14,115	6	2,353
Nov. 29	11,723	5	2,345	Nov. 27	12,278	5	2,456
Dec. 6	13,739	6	2,290	Dec. 4	12,975	6	2,163
Dec. 13	14,273	6	2,379	Dec. 11	13,903	6	2,317
Dec. 20	13,462	6	2,244	Dec. 18	14,360	6	2,393
Dec. 27	8,274	3.6	2,298	Dec. 25	10,790	5	2,158
Jan. 3	[1]5,071	[1]3	[2]1,690	Jan. 1	[1]11,243	5	2,249
Total or average[3]	648,438	298.2	2,175	Total or average[3]	678,685	293.1	2,316

[1]Figures represent production and number of working days in that part of the week included in the calendar year shown.
[2]Average daily output for the working days in the calendar year shown.
[3]Data may not add to totals shown because of independent rounding.

Table 4.—Production of bituminous coal and lignite in the United States, by State and month, 1976 (final)[1]

(Thousand short tons)

State	January	February	March	April	May	June	July	August	September	October	November	December	Total[2]
Alabama	1,755	1,839	1,975	1,774	1,720	1,779	1,352	1,785	1,741	2,019	1,967	1,831	21,537
Alaska	62	72	82	50	28	50	74	48	48	61	63	68	706
Arizona	835	823	862	819	892	1,044	839	830	911	813	943	809	10,420
Arkansas	42	46	43	47	43	43	43	48	44	45	46	44	534
Colorado	732	672	775	831	763	749	679	909	866	798	795	868	9,437
Georgia	16	15	16	15	16	16	15	16	15	16	15	15	186
Illinois	4,916	5,043	5,293	5,180	5,076	4,868	3,645	3,671	5,234	5,166	5,075	5,072	58,239
Indiana	2,055	2,075	2,129	2,246	2,226	2,234	1,882	1,845	1,834	2,311	2,292	2,240	25,369
Iowa	52	50	60	49	50	52	50	50	52	50	50	51	616
Kansas	50	52	53	55	51	54	55	50	52	40	40	38	590
Kentucky:													
Eastern	5,942	6,139	7,881	7,832	7,398	8,006	6,987	8,546	8,533	8,015	7,685	8,174	91,138
Western	4,027	4,157	4,722	5,002	4,431	4,608	3,801	4,573	4,429	4,698	4,633	3,753	52,834
Total	9,969	10,296	12,603	12,834	11,829	12,614	10,788	13,119	12,962	12,713	12,318	11,927	143,972
Maryland	205	218	244	242	266	272	265	261	212	220	201	224	2,830
Missouri	545	579	581	475	546	521	337	476	514	590	465	445	6,075
Montana	1,741	1,761	1,975	2,160	2,271	2,448	2,017	2,249	2,339	2,534	2,397	2,339	26,231
New Mexico	749	835	874	749	758	815	714	777	759	896	899	935	9,760
North Dakota	1,025	1,023	1,047	711	809	876	764	935	973	984	973	982	11,102
Ohio	3,635	3,677	4,036	4,175	4,019	4,343	3,148	3,655	4,509	3,786	3,730	3,869	46,582
Oklahoma	287	312	353	196	258	242	209	309	322	365	403	379	3,635
Pennsylvania	6,560	6,909	7,913	7,496	7,483	7,394	5,515	6,764	7,556	7,401	7,380	7,406	85,777
Tennessee	670	710	776	788	742	869	752	796	802	774	795	809	9,283
Texas	1,073	1,050	1,194	1,028	1,172	1,316	1,282	1,274	1,264	1,206	1,089	1,115	14,063
Utah	643	689	768	647	624	673	485	730	720	724	667	597	7,967
Virginia	3,323	3,355	3,520	3,706	3,854	4,003	2,839	3,223	3,422	2,964	2,922	2,865	39,996
Washington	310	348	339	326	353	384	294	306	338	346	381	384	4,109
West Virginia	9,240	9,245	10,662	10,132	9,703	9,545	4,169	6,819	10,320	9,285	9,604	10,110	108,834
Wyoming	2,078	2,079	2,745	2,414	2,382	2,476	2,106	2,677	2,825	2,792	3,270	2,992	30,836
Total[2]	52,568	53,773	60,918	59,145	57,934	59,680	44,318	53,622	60,634	58,899	58,780	58,414	678,685

[1]Figures are based principally upon railroad carloadings and river shipments supplemented by direct reports from certain local sources. Estimates for coal shipped by truck and used at the mines are included, and the totals represent output for all mines producing 1,000 tons or more per year.
[2]Data may not add to totals shown because of independent rounding.

Table 5.—Production of bituminous coal and lignite in the United States, in 1976, by State and type of mining

(Thousand short tons)

State	Underground	Surface	Total[1]
Alabama	7,406	14,131	21,537
Alaska	--	706	706
Arizona	--	10,420	10,420
Arkansas	W	W	534
Colorado	3,283	6,154	9,437
Georgia	--	186	186
Illinois	31,008	27,231	58,239
Indiana	437	24,931	25,369
Iowa	W	W	616
Kansas	--	590	590
Kentucky:			
Eastern	40,551	50,587	91,138
Western	23,921	28,913	52,834
Total[1]	64,471	79,500	143,972
Maryland	W	W	2,830
Missouri	--	6,075	6,075
Montana	--	26,231	26,231
New Mexico	W	W	9,760
North Dakota	--	11,102	11,102
Ohio	16,626	29,956	46,582
Oklahoma	--	3,635	3,635
Pennsylvania	43,759	42,018	85,777
Tennessee	4,428	4,855	9,283
Texas (lignite)	--	14,063	14,063
Utah	7,967	--	7,967
Virginia	26,055	13,940	39,996
Washington	5	4,104	4,109
West Virginia	87,559	21,275	108,834
Wyoming	524	30,312	30,836
Undistributed	1,350	12,390	--
Total[1]	294,880	383,805	678,685

W Withheld to avoid disclosing individual company confidential data.
[1]Data may not add to totals shown because of independent rounding.

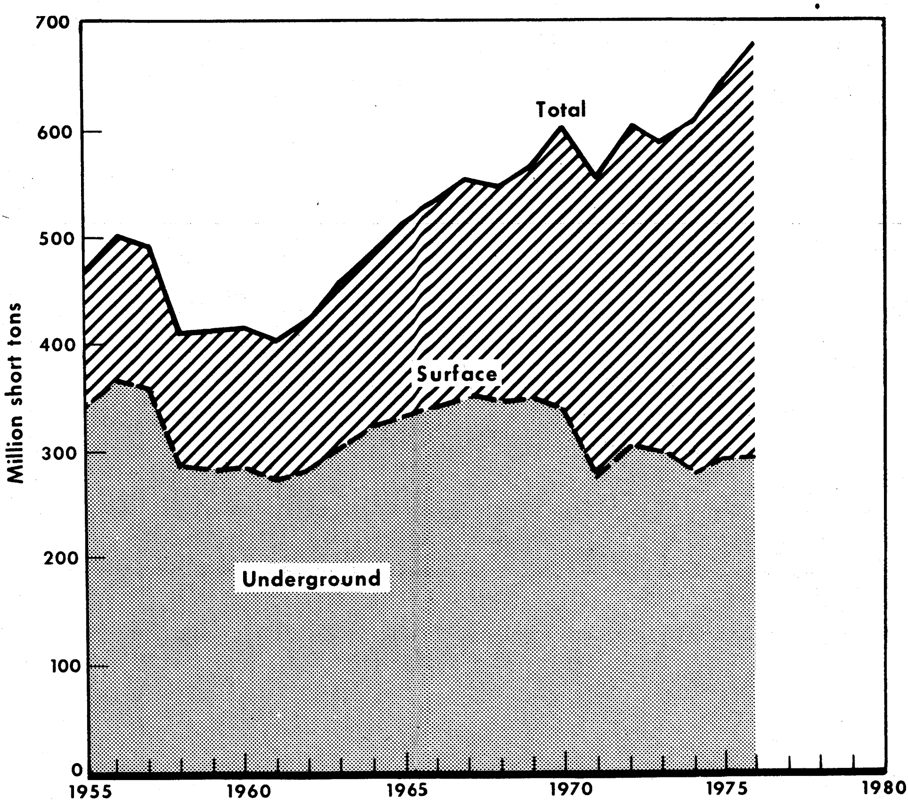

Figure 1.—Production of bituminous coal and lignite, by type of mining in the United States.

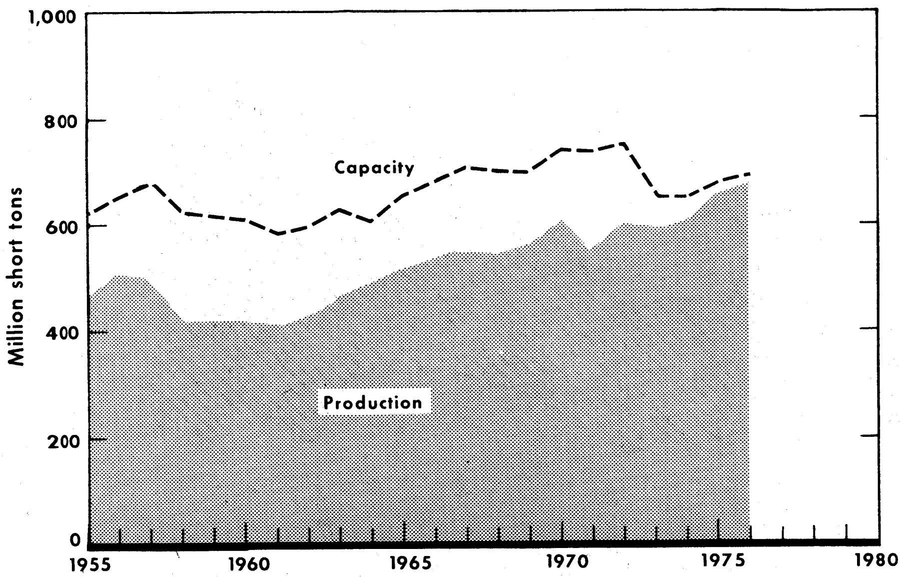

Figure 2.—Trends of bituminous coal and lignite production, realization, and mine capacity in the United States.

Table 6.—Number of mines, production, value, men working daily, days worked, and output per man per hour and per day at bituminous coal and lignite mines in the United States, in 1976, by State

State	Number of active mines	Production (thousand short tons)					Average value per ton[4]	Average number of men working daily	Average number of days worked	Average tons per man per hour	Average tons per man per day
		Shipped by rail or water[1]	Shipped by truck	Mine-mouth generating plants	All other[2]	Total[3]					
Alabama	257	12,114	6,908	2,116	399	21,537	$28.37	9,259	217	1.39	10.72
Alaska	1	575	131	--	--	706	W	80	250	5.17	35.31
Arizona	2	6,159	--	--	4,260	10,420	W	556	271	8.64	69.12
Arkansas	12	480	54	--	--	534	36.15	282	216	1.10	8.76
Colorado	36	7,726	1,678	10	24	9,437	15.30	1,514	241	3.27	25.87
Georgia	3	161	25	--	--	186	33.15	95	250	.78	7.84
Illinois	62	46,896	4,316	6,741	287	58,239	15.90	13,272	264	2.11	16.61
Indiana	64	19,263	6,066	2	38	25,369	12.34	3,769	243	3.26	27.72
Iowa	12	148	467	--	1	616	13.56	140	237	2.16	18.54
Kansas	6	451	133	--	6	590	19.45	114	254	2.45	20.39
Kentucky:											
Eastern	2,054	82,825	7,555	585	173	91,138	23.03	29,481	209	1.84	14.76
Western	161	44,206	2,452	6,144	32	52,834	14.18	10,012	253	2.62	20.84
Total[3]	2,215	127,031	10,007	6,729	205	143,972	19.79	39,493	221	2.07	16.53
Maryland	64	1,490	1,337	--	3	2,830	21.90	737	241	2.11	15.93
Missouri	13	1,877	333	3,861	4	6,075	9.37	799	310	3.30	24.53
Montana	7	24,671	19	1,542	--	26,231	4.90	715	304	15.18	120.67
New Mexico	7	1,735	1	7,980	44	9,760	W	1,004	233	5.26	41.70
North Dakota (lignite)	11	5,221	1,879	3,995	7	11,102	3.74	429	276	12.24	93.70
Ohio	297	26,955	12,494	6,767	364	46,582	16.61	15,004	217	1.77	14.33
Oklahoma	37	3,232	397	--	6	3,635	15.98	1,004	211	2.07	17.14
Pennsylvania	854	50,815	26,688	7,873	401	85,777	25.33	32,359	241	1.34	11.02
Tennessee	185	5,672	3,489	122	--	9,283	16.31	4,806	195	1.29	9.91
Texas (lignite)	5	--	298	11,766	2,000	14,063	W	902	215	9.09	72.49
Utah	24	5,378	1,135	865	589	7,967	22.93	2,614	221	1.74	13.79
Virginia	795	34,268	5,588	--	139	39,996	24.12	15,994	241	1.32	10.40
Washington	4	--	25	4,084	--	4,109	W	531	256	3.78	30.18
West Virginia	1,167	96,435	6,134	6,156	109	108,834	30.12	54,366	232	1.07	8.64
Wyoming	21	21,922	234	8,573	108	30,836	7.00	2,442	243	6.51	51.91
Total[3]	6,161	500,676	89,834	79,182	8,994	678,685	19.43	202,280	232	1.80	14.46

W Withheld to avoid disclosing individual company confidential data.
[1]Includes coal loaded at mines directly into railroad cars or river barges, hauled by trucks to railroad siding, and hauled by trucks to waterways.
[2]Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for other purposes at mine, and shipped by slurry pipeline in Arizona.
[3]Data may not add to totals shown because of independent rounding.
[4]Value received or charged for coal, f.o.b. mine. Includes a value, estimated by producer, for coal not sold.

Table 7.—Average value per ton, f.o.b. mines, of bituminous coal and lignite produced in the United States, by State

State	1975 Under-ground	1975 Surface	1975 Total	1976 Under-ground	1976 Surface	1976 Total
Alabama	$33.77	$22.87	$26.53	$35.73	$24.52	$28.37
Alaska	--	W	W	--	W	W
Arizona	--	W	W	--	W	W
Arkansas	--	32.76	32.76	W	W	36.15
Colorado	27.16	8.86	16.53	27.90	8.91	15.30
Georgia	--	W	W	--	33.15	33.15
Illinois	16.30	12.72	14.64	17.76	13.78	15.90
Indiana	12.00	11.14	11.15	W	12.26	12.34
Iowa	10.62	11.72	11.08	W	W	13.56
Kansas	--	19.78	19.78	--	19.45	19.45
Kentucky:						
Eastern	27.03	15.35	20.79	26.37	20.36	23.03
Western	13.73	10.91	12.16	15.12	13.41	14.18
Total	21.96	13.57	17.40	22.20	17.83	19.79
Maryland	17.97	19.44	19.38	W	W	21.90
Missouri	--	8.52	8.52	--	9.37	9.37
Montana	--	5.06	5.06	--	4.90	4.90
New Mexico	W	W	W	W	W	W
North Dakota (lignite)	--	3.17	3.17	--	3.74	3.74
Ohio	18.76	15.23	16.40	17.78	15.96	16.61
Oklahoma	--	16.69	16.69	--	15.98	15.98
Pennsylvania	30.41	19.08	25.09	32.73	17.63	25.33
Tennessee	15.76	18.25	17.10	16.00	16.58	16.31
Texas (lignite)	--	W	W	--	W	W
Utah	19.84	--	19.84	22.93	--	22.93
Virginia	34.44	22.98	30.46	26.73	19.24	24.12
Washington	20.03	W	W	W	W	W
West Virginia	30.60	24.04	29.35	31.64	23.86	30.12
Wyoming	W	6.61	6.74	W	W	7.00
Total	26.28	13.43	19.23	26.56	13.96	19.43

W Withheld to avoid disclosing individual company confidential data.

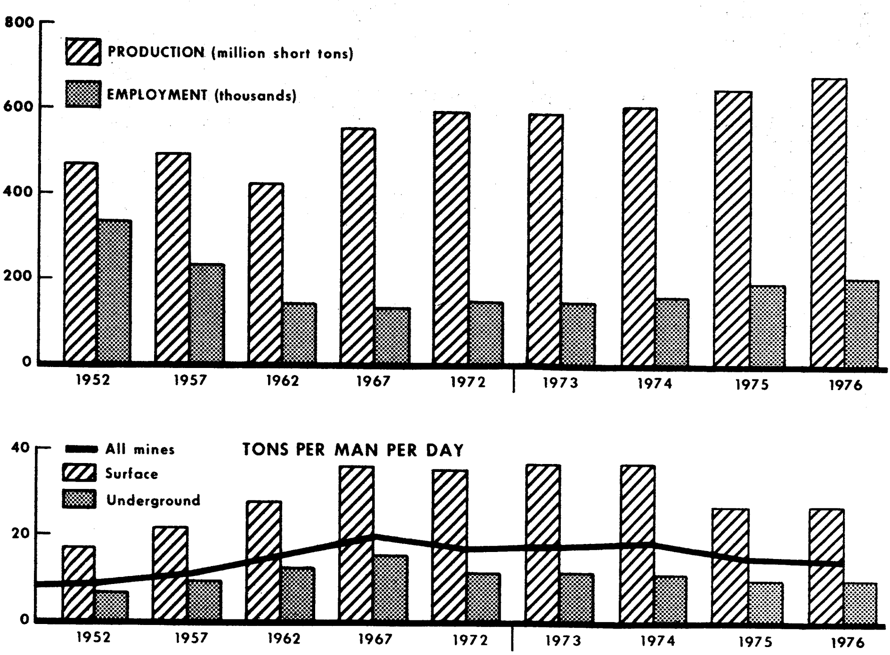

Figure 3.—Trends in employment and output per man at bituminous coal and lignite mines in the United States.

Table 8.—Number of mines, men working daily, days active, and output per man per day and per hour at bituminous coal and lignite mines in the United States, in 1976, by State

State	Number of mines		Average number of men working daily			Average number of days worked			Average tons per man per day			Average tons per man per hour		
	Underground	Surface	Underground	Surface	Total	Underground	Surface	Total	Underground	Surface	Total	Underground	Surface	Total
Alabama	21	236	5,294	3,965	9,259	211	225	217	6.63	15.84	10.72	0.85	2.07	1.39
Alaska	--	1	--	80	80	--	250	250	--	35.31	35.31	--	5.17	5.17
Arizona	--	2	--	556	556	--	271	271	--	69.12	69.12	--	8.64	8.64
Arkansas	1	11	29	253	282	NA	215	216	NA	9.26	8.76	NA	1.16	1.10
Colorado	21	15	1,082	432	1,514	244	245	241	13.05	58.17	25.87	1.64	7.65	3.27
Georgia	--	3	--	95	95	--	250	250	--	7.84	7.84	--	.78	.78
Illinois	23	39	9,150	4,122	13,272	253	290	264	13.42	22.78	16.61	1.69	2.96	2.11
Indiana	2	62	138	3,631	3,769	237	243	243	13.35	28.25	27.72	1.67	3.32	3.26
Iowa	2	10	60	80	140	268	214	237	19.19	17.93	18.54	2.13	2.20	2.16
Kansas	--	6	--	114	114	--	254	254	--	20.39	20.39	--	2.45	2.45
Kentucky:														
Eastern	827	1,227	17,883	11,598	29,481	215	202	209	10.57	21.66	14.76	1.40	2.47	1.84
Western	28	133	6,270	3,742	10,012	258	245	253	14.78	31.54	20.84	1.85	3.98	2.62
Total	855	1,360	24,153	15,340	39,493	226	212	221	11.82	24.44	16.53	1.54	2.87	2.07
Maryland	2	62	55	682	737	216	243	241	14.74	16.02	15.93	1.88	2.13	2.11
Missouri	--	13	--	799	799	--	310	310	--	24.53	24.53	--	3.30	3.30
Montana	--	7	--	715	715	--	304	304	--	120.67	120.67	--	15.18	15.18
New Mexico	2	5	385	619	1,004	214	245	233	10.16	58.79	41.70	1.30	7.36	5.26
North Dakota	--	11	--	429	429	--	276	276	--	93.70	93.70	--	12.24	12.24
Ohio	31	266	9,760	5,244	15,004	198	251	217	8.59	22.76	14.33	1.06	2.81	1.77
Oklahoma	--	37	--	1,004	1,004	--	211	211	--	17.14	17.14	--	2.07	2.07
Pennsylvania	140	714	22,736	9,623	32,359	238	248	241	8.10	17.64	11.02	.99	2.13	1.34
Tennessee	75	110	2,558	2,248	4,806	225	161	195	7.69	13.43	9.91	.96	1.86	1.29
Texas	--	5	--	902	902	--	215	215	--	72.49	72.49	--	9.09	9.09
Utah	24	--	2,614	--	2,614	221	--	221	13.79	--	13.79	1.74	--	1.74
Virginia	399	396	13,121	2,873	15,994	250	198	241	7.95	24.49	10.40	1.03	2.77	1.32
Washington	1	3	2	529	531	NA	257	256	NA	30.18	30.18	NA	3.78	3.78
West Virginia	819	348	48,856	5,510	54,366	231	239	232	7.76	16.19	8.64	.95	2.11	1.07
Wyoming	4	17	267	2,175	2,442	245	243	243	8.00	57.35	51.91	.89	7.31	6.51
Total	2,422	3,739	140,260	62,020	202,280	231	235	232	9.10	26.40	14.46	1.14	3.25	1.80

NA Not available.

Table 9.—Production, shipments, and value at bituminous coal and lignite mines, in 1976, by State and county

(Thousand short tons)

State and county	Production: Underground: Number of mines	Production: Underground: Quantity	Production: Surface: Number of mines	Production: Surface: Quantity	Shipments: Rail or water[1]	Shipments: Truck	Shipments: Mine-mouth generating plants	Shipments: All other[2]	Shipments: Total[3]	Average value per ton[4]
Alabama:										
Bibb	--	--	4	169	126	43	--	--	169	$28.82
Blount	1	4	19	685	434	254	--	--	688	26.57
Cherokee	--	--	8	105	69	35	--	--	105	24.47
Cullman	--	--	18	738	190	548	--	--	738	23.93
De Kalb	--	--	13	367	109	246	12	--	367	26.49
Etowah	--	--	2	W	--	W	--	--	W	W
Fayette	1	W	4	W	896	106	--	--	1,001	32.41
Franklin	--	--	9	248	--	248	--	--	248	24.25
Jackson	1	W	4	639	624	39	--	--	663	W
Jefferson	12	3,892	27	2,364	4,198	1,882	86	91	6,256	32.94
Lamar	--	--	1	118	--	118	--	--	118	W
Marion	2	W	24	W	193	554	--	--	747	19.93
St. Clair	--	--	12	98	--	98	--	--	98	19.26
Shelby	--	--	3	504	498	6	--	--	504	W
Tuscaloosa	--	--	21	2,757	1,955	495	--	308	2,757	24.64
Walker	4	2,696	51	3,853	2,746	1,784	2,019	--	6,549	28.42
Winston	--	--	16	505	76	429	--	--	505	24.33
Total[3]	21	7,406	236	14,131	12,114	6,908	2,116	399	21,537	28.37
Alaska: Yukon River	--	--	1	706	575	131	--	--	706	W
Arizona: Navajo	--	--	2	10,420	6,159	--	--	4,260	10,420	W
Arkansas:										
Franklin	--	--	4	114	106	8	--	--	114	W
Johnson	--	--	4	159	124	35	--	--	159	W
Logan	--	--	1	10	--	10	--	--	10	W
Pope	--	--	1	13	13	--	--	--	13	W
Sebastian	1	30	1	208	238	--	--	--	238	W
Total[3]	1	30	11	504	480	54	--	--	534	36.15
Colorado:										
Delta	2	188	--	--	180	--	--	8	188	W
Fremont	1	41	3	50	--	91	--	--	91	W
Gunnison	6	1,057	--	--	1,020	22	--	15	1,057	W
Jackson	--	--	2	270	270	--	--	--	270	W
La Plata	1	17	--	--	--	17	--	--	17	W

Las Animas	1	619	2	31	619	31	--	--	649	W
Mesa	1	43	--	--	31	2	10	--	43	W
Moffat	1	349	1	166	515	--	--	--	515	W
Montrose	--	--	1	98	--	98	--	--	98	W
Pitkin	5	889	--	--	889	--	--	--	889	W
Routt	1	14	6	5,539	4,148	1,405	--	--	5,553	W
Weld	2	67	--	--	54	12	--	1	67	W
Total[3]	21	3,283	15	6,154	7,726	1,678	10	24	9,437	15.30
Georgia:										
Chattooga	--	--	1	160	144	15	--	--	160	W
Dade	--	--	1	10	6	4	--	--	10	W
Walker	--	--	1	16	11	6	--	--	16	W
Total[3]	--	--	3	186	161	25	--	--	186	33.15
Illinois:										
Christian	1	W	--	--	W	W	W	W	W	W
Douglas	2	W	--	--	W	W	W	W	W	W
Franklin	3	W	--	--	W	W	W	W	W	W
Fulton	--	--	4	2,894	2,549	341	--	4	2,894	--
Gallatin	1	W	1	W	W	W	W	W	W	--
Jackson	--	--	5	761	620	52	--	90	761	--
Jefferson	3	W	1	W	4,980	144	--	48	5,172	--
Knox	--	--	1	W	W	W	W	W	W	W
Macoupin	2	W	--	--	W	W	W	W	W	W
Montgomery	1	W	--	--	W	W	W	W	W	W
Peoria	--	--	1	W	W	W	W	W	W	W
Perry	--	--	5	W	11,133	205	--	40	11,379	--
Randolph	3	W	4	W	4,952	210	2,964	--	8,127	--
St. Clair	1	W	1	W	W	W	W	W	W	--
Saline	2	W	4	W	2,520	48	--	5	2,573	--
Stark	--	--	1	W	W	W	W	W	W	W
Vermilion	--	--	1	W	W	W	W	W	W	W
Wabash	1	W	--	--	W	W	W	W	W	W
Williamson	3	W	10	W	2,027	438	2	13	2,480	--
Undistributed	--	--	--	23,576	18,115	2,878	3,775	87	24,853	--
Total[3]	23	31,008	39	27,231	46,896	4,316	6,741	287	58,239	15.90
Indiana:										
Clay	--	--	8	1,328	699	625	--	4	1,328	W
Daviess	--	--	3	266	79	187	--	--	266	W
Dubois	--	--	2	W	W	W	W	--	280	W
Fountain	--	--	1	W	W	W	W	--	41	W
Gibson	--	--	1	W	W	W	W	W	W	W
Greene	--	--	2	953	789	214	--	--	953	W
Knox	--	--	2	670	499	168	2	--	670	W
Owen	--	--	2	13	--	13	--	--	13	W

See footnotes at end of table.

Table 9.—Production, shipments, and value at bituminous coal and lignite mines, in 1976, by State and county —Continued

(Thousand short tons)

State and county	Production: Underground: Number of mines	Production: Underground: Quantity	Production: Surface: Number of mines	Production: Surface: Quantity	Shipments: Rail or water[1]	Shipments: Truck	Shipments: Mine-mouth generating plants	Shipments: All other[2]	Shipments: Total[3]	Average value per ton[4]
Indiana —Continued										
Perry	--	--	1	28	3	25	--	--	28	W
Pike	1	W	11	5,786	4,602	1,233	--	21	5,855	W
Spencer	--	--	9	571	425	146	--	--	571	W
Sullivan	--	--	5	2,502	2,005	494	--	3	2,502	W
Vermillion	--	--	2	2,678	2,094	584	--	--	2,678	W
Vigo	--	--	2	26	--	26	--	--	26	W
Warrick	1	W	11	9,387	8,087	1,658	--	10	9,755	W
Undistributed	--	--	--	723	31	693	--	--	403	--
Total[3]	2	437	62	24,931	19,263	6,066	2	38	25,369	$12.34
Iowa:										
Lucas	1	W	--	--	W	W	W	W	W	W
Mahaska	--	--	5	254	148	105	--	1	254	--
Marion	--	--	4	51	--	51	--	--	51	--
Monroe	1	W	--	--	W	W	W	W	W	W
Wapello	--	--	1	2	--	2	--	--	2	W
Undistributed	--	309	--	--	--	309	--	--	309	--
Total[3]	2	309	10	307	148	467	--	1	616	13.56
Kansas:										
Bourbon	--	--	2	W	W	W	--	W	W	W
Cherokee	--	--	1	W	W	W	--	W	W	W
Crawford	--	--	2	W	W	W	--	W	W	W
Wilson	--	--	1	W	W	W	--	W	W	W
Total[3]	--	--	6	590	451	133	--	6	590	19.45
Kentucky:										
Eastern:										
Bell	17	1,265	46	3,052	4,187	130	--	--	4,317	NA
Boyd	--	--	7	267	194	73	--	--	267	NA
Breathitt	2	20	64	6,442	5,760	702	--	--	6,462	NA
Carter	--	--	34	332	119	213	--	--	332	NA
Clay	19	220	50	568	566	222	--	--	788	NA

Elliott	--	--	12	371	169	202	--	--	371	NA
Floyd	88	2,213	38	2,335	4,062	486	--	--	4,548	NA
Greenup	--	--	13	211	110	102	--	--	213	NA
Harlan	93	8,540	75	1,978	9,803	687	--	28	10,518	NA
Jackson	2	W	24	603	708	69	--	28	804	NA
Johnson	7	248	74	3,477	3,377	348	--	--	3,725	NA
Knott	77	2,788	50	1,583	4,050	321	--	--	4,371	NA
Knox	6	115	45	990	921	83	--	101	1,105	NA
Laurel	3	38	60	1,177	957	259	--	--	1,215	NA
Lawrence	--	--	29	1,163	909	121	133	--	1,163	NA
Lee	--	--	12	267	131	135	--	--	267	NA
Leslie	49	1,804	77	2,519	3,616	271	436	--	4,323	NA
Letcher	69	2,833	39	1,283	3,672	429	--	16	4,116	NA
McCreary	3	W	8	274	592	44	--	--	637	NA
Magoffin	5	71	42	2,177	2,184	65	--	--	2,249	NA
Martin	21	2,786	57	5,428	7,806	409	--	--	8,215	NA
Menifee	--	--	1	3	--	3	--	--	3	NA
Morgan	--	--	34	604	471	133	--	--	604	NA
Owsley	1	W	14	211	188	53	--	--	241	NA
Perry	54	2,547	111	6,349	8,689	206	--	--	8,895	NA
Pike	305	14,220	116	4,782	17,682	1,319	--	1	19,002	NA
Pulaski	3	W	8	322	400	61	--	--	461	NA
Rockcastle	--	--	5	52	--	52	--	--	52	NA
Wayne	--	--	4	174	130	44	--	--	174	NA
Whitley	3	W	68	1,377	1,371	115	--	--	1,485	NA
Wolfe	--	--	10	214	--	198	16	--	214	NA
Undistributed	--	843	--	--	--	--	--	--	--	--
Total[3]	827	40,551	1,227	50,587	82,825	7,555	585	173	91,138	23.03
Western:										
Butler	1	54	25	831	391	468	--	26	885	NA
Christian	--	--	4	220	147	73	--	--	220	NA
Daviess	--	--	6	1,005	928	77	--	--	1,005	NA
Grayson	--	--	1	1	--	1	--	--	1	NA
Hancock	--	--	4	131	129	2	--	--	131	NA
Henderson	2	1,034	--	--	--	--	1,034	--	1,034	NA
Hopkins	8	5,277	31	4,582	9,706	153	--	--	9,859	NA
McLean	--	--	4	751	751	--	--	--	751	NA
Muhlenberg	7	5,044	12	15,085	13,665	1,357	5,110	--	20,129	NA
Ohio	3	3,125	31	5,780	8,834	70	--	1	8,905	NA
Union	6	7,632	--	--	7,626	--	--	6	7,632	NA
Warren	--	--	2	15	--	15	--	--	15	NA
Webster	1	1,755	13	512	2,030	237	--	--	2,267	NA
Total[3]	28	23,921	133	28,913	44,206	2,452	6,144	32	52,834	14.18
Total Kentucky	855	64,471	1,360	79,500	127,031	10,007	6,729	205	143,972	19.79

See footnotes at end of table.

Table 9.—Production, shipments, and value at bituminous coal and lignite mines, in 1976, by State and county —Continued

(Thousand short tons)

State and county	Production: Underground: Number of mines	Production: Underground: Quantity	Production: Surface: Number of mines	Production: Surface: Quantity	Shipments: Rail or water[1]	Shipments: Truck	Shipments: Mine-mouth generating plants	Shipments: All other[2]	Shipments: Total[3]	Average value per ton[4]
Maryland:										
Allegany	--	--	29	980	571	406	--	3	980	$27.25
Garrett	2	175	33	1,675	919	931	--	--	1,850	20.77
Total[3]	2	175	62	2,655	1,490	1,337	--	3	2,830	21.90
Missouri:										
Barton	--	--	1	W	W	W	W	W	W	W
Bates	--	--	1	W	W	W	W	W	W	W
Henry	--	--	2	W	W	W	W	W	W	W
Howard	--	--	1	W	W	W	W	W	W	W
Macon	--	--	1	W	W	W	W	W	W	W
Putnam	--	--	1	W	W	W	W	W	W	W
Randolph	--	--	4	W	W	W	W	W	W	W
Vernon	--	--	2	W	W	W	W	W	W	W
Total[3]	--	--	13	6,075	1,877	333	3,861	4	6,075	9.37
Montana:										
Big Horn	--	--	2	W	W	W	W	--	W	W
Musselshell	--	--	2	W	W	W	W	--	W	W
Richland	--	--	1	W	W	W	W	--	W	W
Rosebud	--	--	2	W	W	W	W	--	W	W
Total[3]	--	--	7	26,231	24,671	19	1,542	--	26,231	4.90
New Mexico:										
Colfax	2	W	1	W	W	W	W	W	W	W
McKinley	--	--	2	W	W	W	W	W	W	W
San Juan	--	--	2	W	W	W	W	W	W	W
Total[3]	2	836	5	8,924	1,735	1	7,980	44	9,760	W

North Dakota:										
Adams	--	--	1	W	W	W	W	W	W	W
Bowman	--	--	1	W	W	W	W	W	W	W
Burke	--	--	1	W	W	W	W	W	W	W
Grant	--	--	1	W	W	W	W	W	W	W
Mercer	--	--	3	W	W	W	W	W	W	W
Oliver	--	--	2	W	W	W	W	W	W	W
Stark	--	--	1	W	W	W	W	W	W	W
Ward	--	--	1	W	W	W	W	W	W	W
Total[3]	--	--	11	11,102	5,221	1,879	3,995	7	11,102	3.74
Ohio:										
Athens	--	--	4	111	78	34	--	--	111	W
Belmont	7	6,925	36	7,118	13,060	983	--	--	14,044	17.45
Carroll	--	--	9	268	--	268	--	--	268	15.43
Columbiana	2	W	23	W	40	921	9	--	970	16.64
Coshocton	2	W	17	W	401	1,034	440	--	1,875	17.97
Gallia	--	--	5	428	W	W	W	W	W	W
Guernsey	1	W	7	W	508	172	--	6	686	16.88
Harrison	5	2,979	20	3,875	6,162	340	--	352	6,854	17.47
Hocking	--	--	10	710	98	612	--	--	710	12.99
Holmes	--	--	4	555	--	555	--	--	555	13.91
Jackson	1	W	20	W	301	727	--	--	1,028	15.20
Jefferson	2	W	29	W	1,767	1,899	--	1	3,668	14.66
Lawrence	--	--	5	206	87	119	--	--	206	12.95
Mahoning	--	--	8	290	--	290	--	--	290	17.02
Meigs	2	W	--	--	W	W	W	W	W	W
Monroe	2	W	--	--	W	W	W	W	W	W
Morgan	--	--	1	W	W	W	W	W	W	W
Muskingum	2	W	14	W	24	914	4,080	--	5,018	15.69
Noble	--	--	3	323	17	306	--	--	323	W
Perry	3	W	7	W	1,562	679	--	1	2,242	13.07
Scioto	--	--	1	W	W	W	W	W	W	W
Stark	--	--	12	410	--	676	--	--	676	14.98
Tuscarawas	--	--	16	1,307	581	723	--	4	1,307	16.38
Vinton	2	W	13	W	668	1,152	437	--	2,256	15.54
Washington	--	--	1	W	W	W	W	W	W	W
Wayne	--	--	1	W	W	W	W	W	W	W
Undistributed	--	6,722	--	14,355	1,601	90	1,801	--	3,495	--
Total[3]	31	16,626	266	29,956	26,955	12,494	6,767	364	46,582	16.61
Oklahoma:										
Craig	--	--	9	2,195	1,949	246	--	1	2,195	10.94
Haskell	--	--	6	190	180	10	--	--	190	38.09
Latimer	--	--	1	13	--	13	--	--	13	W
Le Flore	--	--	6	249	236	13	--	--	249	45.71
Muskogee	--	--	1	W	W	--	--	--	W	W
Nowata	--	--	2	56	48	8	--	--	56	W

See footnotes at end of table.

Table 9.—Production, shipments, and value at bituminous coal and lignite mines, in 1976, by State and county —Continued

(Thousand short tons)

State and county	Production				Shipments					
	Underground		Surface							
	Number of mines	Quantity	Number of mines	Quantity	Rail or water[1]	Truck	Mine-mouth generating plants	All other[2]	Total[3]	Average value per ton[4]
Oklahoma —Continued										
Okmulgee	--	--	2	188	127	61	--	--	188	W
Pittsburg	--	--	2	62	31	27	--	4	62	W
Rogers	--	--	7	519	500	19	--	--	519	$16.38
Wagoner	--	--	1	W	W	--	--	--	W	W
Undistributed	--	--	--	163	161	--	--	--	163	--
Total[3]	--	--	37	3,635	3,232	397	--	6	3,635	15.98
Pennsylvania:										
Allegheny	8	3,049	16	606	2,397	1,258	--	--	3,655	30.42
Armstrong	10	4,247	61	3,488	1,708	2,860	3,105	62	7,734	19.08
Beaver	1	82	6	106	60	112	--	17	188	21.72
Bedford	--	--	6	118	11	95	--	12	118	W
Blair	--	--	1	1	--	1	--	--	1	W
Butler	1	243	22	1,095	557	772	6	4	1,338	21.70
Cambria	17	5,024	25	2,137	5,656	1,428	73	4	7,161	39.71
Centre	1	603	10	659	916	338	--	8	1,262	19.07
Clarion	--	--	50	5,222	3,521	1,616	29	57	5,222	17.25
Clearfield	4	674	96	8,119	5,085	3,681	--	27	8,793	19.57
Clinton	--	--	12	433	185	248	--	--	433	15.91
Elk	--	--	15	665	195	470	--	--	665	17.43
Fayette	3	755	64	2,317	2,117	934	--	22	3,073	20.84
Fulton	--	--	1	13	--	13	--	--	13	W
Greene	16	6,888	21	1,131	7,114	886	--	18	8,019	32.15
Huntingdon	--	--	1	4	--	4	--	--	4	W
Indiana	32	7,986	53	2,740	4,016	2,170	4,509	31	10,726	22.89
Jefferson	6	117	45	2,536	1,922	731	--	1	2,653	18.10
Lawrence	--	--	18	685	111	449	125	--	685	15.72
Lycoming	--	--	3	491	35	456	--	--	491	W
Mercer	--	--	5	400	87	313	--	--	400	19.86
Somerset	24	2,619	78	3,810	3,164	3,186	6	73	6,430	23.71
Tioga	--	--	4	636	--	636	--	--	636	W
Venango	--	--	14	792	78	713	--	--	792	18.30
Washington	13	10,664	29	1,807	10,853	1,614	--	4	12,471	33.25
Westmoreland	4	807	58	2,004	1,027	1,701	21	63	2,811	21.27

Total[3]	140	43,759	714	42,018	50,815	26,688	7,873	401	85,777	25.33
Tennessee:										
Anderson	23	1,524	7	545	448	1,620	--	--	2,068	15.74
Bledsoe	1	W	4	W	28	106	--	--	134	17.47
Campbell	19	441	21	1,245	1,322	363	--	--	1,686	16.95
Claiborne	3	W	5	W	1,327	2	--	--	1,329	16.51
Cumberland	2	W	1	W	W	W	W	--	W	W
Fentress	1	W	11	W	103	437	--	--	540	15.62
Grundy	1	W	2	W	W	W	W	--	W	W
Marion	7	436	7	84	309	210	--	--	520	16.38
Morgan	2	W	14	W	301	394	--	--	694	15.75
Overton	1	W	1	W	W	W	W	--	W	W
Putnam	1	W	--	--	W	W	W	--	W	W
Roane	--	--	1	W	W	W	W	--	W	W
Scott	8	322	31	974	1,220	75	--	--	1,295	15.16
Sequatchie	6	W	2	W	510	80	--	--	590	19.58
Van Buren	--	--	3	W	W	W	W	--	108	18.74
Undistributed	--	1,705	--	2,007	104	202	--	--	319	--
Total[3]	75	4,428	110	4,855	5,672	3,489	122	--	9,283	16.31
Texas:										
Freestone	--	--	1	W	--	W	W	W	W	W
Harrison	--	--	1	W	--	W	W	W	W	W
Hopkins	--	--	1	W	--	W	W	W	W	W
Milam	--	--	1	W	--	W	W	W	W	W
Titus	--	--	1	W	--	W	W	W	W	W
Total[3]	--	--	5	14,063	--	298	11,766	2,000	14,063	W
Utah:										
Carbon	14	3,733	--	--	3,089	116	--	528	3,733	W
Emery	9	3,191	--	--	1,770	548	865	7	3,191	W
Sevier	1	1,043	--	--	519	471	--	53	1,043	W
Total[3]	24	7,967	--	--	5,378	1,135	865	589	7,967	22.93
Virginia:										
Buchanan	238	11,584	109	4,220	12,866	2,938	--	--	15,804	NA
Dickenson	50	3,791	54	1,508	4,833	465	--	--	5,299	NA
Lee	21	630	19	683	1,292	20	--	--	1,313	NA
Russell	9	1,269	19	439	1,530	178	--	--	1,708	NA
Tazewell	24	3,184	14	399	2,948	635	--	--	3,583	NA
Wise	57	5,599	181	6,691	10,799	1,352	--	139	12,290	NA
Total[3]	399	26,055	396	13,940	34,268	5,588	--	139	39,996	24.12

See footnotes at end of table.

Table 9.—Production, shipments, and value at bituminous coal and lignite mines, in 1976, by State and county —Continued

(Thousand short tons)

State and county	Production				Shipments					
	Underground		Surface							
	Number of mines	Quantity	Number of mines	Quantity	Rail or water[1]	Truck	Mine-mouth generating plants	All other[2]	Total[3]	Average value per ton[4]
Washington:										
King	1	5	1	17	--	23	--	--	23	W
Lewis	--	--	2	2,453	--	3	2,451	--	2,453	W
Thurston	--	--	(5)	1,634	--	--	1,634	--	1,634	W
Total[3]	1	5	3	4,104	--	25	4,084	--	4,109	W
West Virginia:										
Barbour	12	956	22	2,080	2,967	48	--	21	3,036	NA
Boone	53	8,154	19	2,205	10,194	165	--	--	10,359	NA
Braxton	3	29	6	124	136	16	--	--	153	NA
Brooke	2	766	4	127	766	127	--	--	893	NA
Clay	5	40	2	22	35	27	--	--	62	NA
Fayette	32	2,004	18	923	2,822	105	--	1	2,927	NA
Gilmer	3	30	2	28	58	--	--	--	58	NA
Grant	3	1,302	2	302	1,225	--	378	--	1,603	NA
Greenbrier	15	494	18	560	1,023	31	--	--	1,055	NA
Harrison	21	3,929	30	1,318	2,151	389	2,702	4	5,247	NA
Kanawha	49	5,438	26	2,379	7,552	265	--	--	7,817	NA
Lewis	1	45	11	351	355	41	--	--	395	NA
Lincoln	3	169	--	--	147	22	--	--	169	NA
Logan	98	7,158	13	1,567	8,429	296	--	--	8,725	NA
McDowell	138	9,451	13	972	9,804	570	--	50	10,423	NA
Marion	9	5,615	6	102	5,663	54	--	--	5,717	NA
Marshall	4	5,135	--	--	2,007	66	3,063	--	5,135	NA
Mason	2	46	--	--	--	46	--	--	46	NA
Mercer	6	807	3	20	818	7	--	2	827	NA
Mineral	--	--	6	355	286	56	12	--	355	NA
Mingo	58	3,782	10	742	4,351	173	--	--	4,524	NA
Monongalia	24	9,634	10	887	10,270	251	--	--	10,520	NA
Nicholas	48	3,901	21	1,262	4,920	243	--	--	5,163	NA
Ohio	2	1,502	--	--	1,415	87	--	--	1,502	NA
Preston	16	975	37	1,538	852	1,661	--	--	2,513	NA
Raleigh	53	5,910	14	853	6,309	429	--	24	6,763	NA
Randolph	23	399	13	695	1,053	41	--	--	1,094	NA
Summers	1	3	--	--	3	--	--	--	3	NA
Taylor	--	--	7	208	201	7	--	--	208	NA

Tucker	--	--	2	363	363	--	--	--	363	NA
Upshur	6	941	16	516	1,370	88	--	--	1,457	NA
Wayne	2	494	--	--	358	136	--	--	494	NA
Webster	16	210	7	308	507	11	--	--	517	NA
Wyoming	111	8,242	10	468	8,024	677	--	8	8,709	NA
Total[3]	819	87,559	348	21,275	96,435	6,134	6,156	109	108,834	$30.12
Wyoming:										
Campbell	--	--	3	W	W	W	W	W	W	W
Carbon	2	W	7	W	11,435	--	--	6	11,441	W
Converse	--	--	1	W	W	W	W	W	W	W
Hot Springs	--	--	1	W	W	W	W	W	W	W
Lincoln	--	--	2	W	W	W	W	W	W	W
Sheridan	--	--	2	W	W	W	W	W	W	W
Sweetwater	2	W	1	W	W	W	W	W	W	W
Total[3]	4	524	17	30,312	21,922	234	8,573	108	30,836	7.00
Total United States[3]	2,422	294,880	3,739	383,805	500,676	89,884	79,182	8,994	678,685	19.43

NA Not available. W Withheld to avoid disclosing individual company confidential data.
[1]Includes coal loaded at mines directly into railroad cars or river barges, hauled by trucks to railroad sidings, and hauled by trucks to waterways.
[2]Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for other purpose at mine, and shipped by slurry pipeline in Arizona.
[3]Data may not add to totals shown because of independent rounding.
[4]Value received or charged for coal, f.o.b. mine. Includes a value, estimated by producer, for coal not sold.
[5]One mine extends into two counties but is counted only in the county where its greater production occurred.

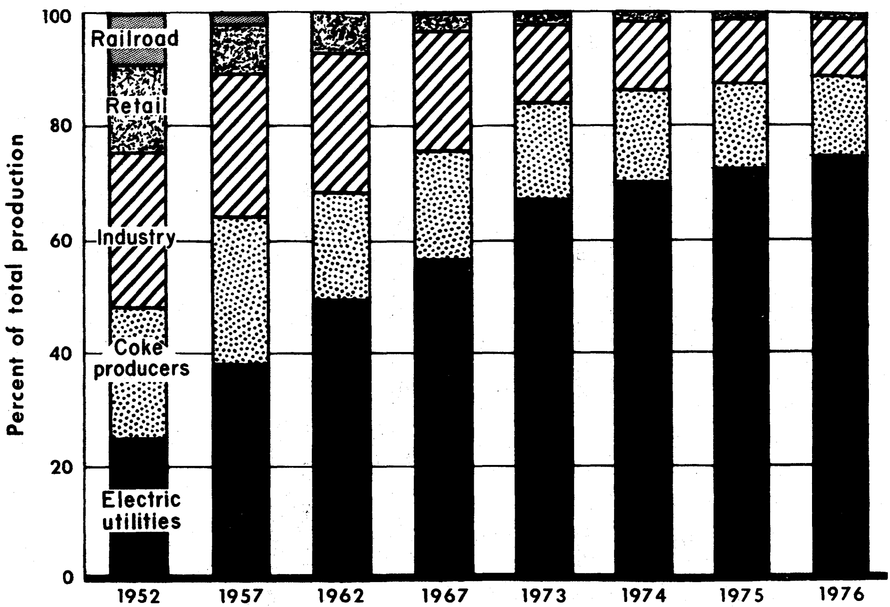

Figure 4.—Percentage of total consumption of bituminous coal and lignite, by consumer class and retail deliveries in the United States.

Table 10.—Consumption of bituminous coal and lignite, by consumer class, and retail deliveries in the United States

(Thousand short tons)

Year and month	Electric power utilities[1]	Bunker, lake vessel and foreign[2]	Manufacturing and mining industries: Beehive coke plants	Manufacturing and mining industries: Oven coke plants	Manufacturing and mining industries: Steel and rolling mills[3]	Manufacturing and mining industries: Other manufacturing and mining industries[4]	Retail deliveries to other consumers[5]	Total of classes shown[6]
1972	[r]350,184	163	1,059	86,213	4,850	67,131	8,748	[r]518,348
1973	[r]387,769	116	1,310	92,324	6,356	60,837	8,200	[r]556,912
1974	[r]390,313	80	1,337	88,410	6,155	57,819	8,840	[r]552,954
1975:								
January	[r]35,695	1	112	7,191	416	5,290	1,121	[r]49,826
February	[r]31,971	1	108	6,923	359	5,662	663	[r]45,687
March	[r]32,679	--	108	7,772	302	5,678	652	[r]47,191
April	[r]30,428	3	100	7,327	254	5,340	366	[r]43,818
May	[r]30,427	4	89	7,193	210	4,776	258	[r]42,957
June	[r]33,322	3	81	6,919	147	4,201	306	[r]44,979
July	[r]36,441	2	91	6,547	114	4,070	444	[r]47,709
August	[r]37,832	2	94	6,470	137	4,322	406	[r]49,263
September	[r]32,484	2	97	6,190	135	4,666	581	[r]44,155
October	[r]32,728	3	94	6,565	171	4,689	690	[r]44,940
November	[r]33,209	2	89	6,396	227	5,308	725	[r]45,956
December	[r]37,268	1	62	6,654	243	5,757	1,070	[r]51,055
Total	[r]404,483	24	1,125	82,147	2,715	59,759	7,282	[r]557,535
1976:								
January	39,868	--	77	6,655	275	5,094	963	52,932
February	34,863	--	77	6,528	246	4,579	540	46,833
March	35,989	--	86	7,176	267	4,621	484	48,623
April	33,680	1	85	6,992	212	4,869	576	46,415
May	33,812	2	85	7,311	194	4,866	411	46,681
June	36,252	1	85	7,069	161	4,512	365	48,445
July	39,709	1	79	7,188	160	4,316	264	51,717
August	40,194	1	74	6,965	195	4,266	387	52,082
September	35,784	2	77	6,831	178	4,377	440	47,689
October	36,683	2	65	6,977	275	4,750	560	49,312
November	38,735	1	66	6,835	300	5,200	740	51,877
December	41,452	1	85	6,856	280	6,300	1,170	56,144
Total	447,021	12	941	83,383	2,743	57,750	6,900	598,750

[r]Revised.
[1]Federal Power Commission.
[2]Bureau of Census, U.S. Department of Commerce, Ore and Coal Exchange.
[3]Estimates based upon reports collected from a selected list of steel and rolling mills.
[4]Estimates based upon reports collected from a selected list of manufacturing plants.
[5]Estimates based upon reports collected from a selected list of retailers. Includes some coal shipped by truck from mine to final destination.
[6]The total of classes shown approximates total consumption. The calculation of consumption from production, imports, exports, and changes in stocks is not as accurate as the "Total of classes shown" because certain significant items of stocks are not included in monthly stocks. These items are stocks on lake and tidewater docks, stocks at other intermediate storage piles between mine and consumer, and coal in transit.

Table 11.—Stocks and days' supply of bituminous coal and lignite in the United States, in 1976, by consumer class

(Thousand short tons)

Date	Electric power utilities[1]	Oven coke plants	Steel and rolling mills	Other manufacturing and mining industries	Retail dealers	Total
			STOCKS			
Jan. 31	104,527	8,115	176	6,249	153	119,220
Feb. 29	103,889	8,514	175	6,266	160	119,004
Mar. 31	107,452	9,334	163	6,362	159	123,470
Apr. 30	111,857	9,931	170	6,303	133	128,394
May 31	118,591	10,612	174	6,509	127	136,013
June 30	122,020	11,257	183	6,546	138	140,144
July 31	114,153	8,715	183	6,469	140	129,660
Aug. 31	109,707	7,258	170	6,544	174	123,853
Sept. 30	114,339	8,194	184	6,974	187	129,878
Oct. 31	117,502	9,037	195	6,700	190	133,624
Nov. 30	118,224	9,605	180	6,800	210	135,019
Dec. 31	116,436	9,804	175	6,900	240	133,555
			DAYS' SUPPLY[2]			
Jan. 31	81	38	20	38	5	70
Feb. 29	86	38	21	40	9	74
Mar. 31	93	40	19	43	10	79
Apr. 30	100	44	24	39	7	83
May 31	109	45	28	41	10	90
June 30	101	48	34	44	11	87
July 31	89	38	35	46	16	78
Aug. 31	85	32	27	48	14	74
Sept. 30	96	36	31	48	13	82
Oct. 31	99	40	22	44	10	84
Nov. 30	92	42	18	39	9	78
Dec. 31	87	44	19	34	6	74

[1]Federal Power Commission.

[2]Days' supply is calculated by dividing the total stocks at the end of the month by the daily average rate of consumption during the same month. By this method, seasonal variation in daily average rate of consumption is not reflected.

Table 12.—Distribution of bituminous coal and lignite, in 1976, by method of movement and consumer use

(Thousand short tons)

Shipments	Electric utilities	Coke and gas plants	Retail dealers	All others	Rail-road fuel	Used at mines and sales to employees
Total shipments to all destinations in the United States, Canada, and Mexico, by all methods of movement and consumer use, and overseas exports	463,058	92,678	4,137	53,202	277	1,362
Shipments to all destinations in the United States, Canada, and Mexico by specific method of movement and consumer use:						
Method of movement:						
All-rail	246,032	51,250	2,183	31,583	--	--
River and ex-river	81,677	22,712	41	3,073	--	--
Great Lakes[1]	16,833	12,016	502	3,752	--	--
Tidewater[2]	1,243	4,101	--	--	--	--
Truck	52,671	2,599	1,411	12,729	--	--
Tramway, conveyor, private railroad	64,602	--	--	2,065	--	--
Method of movement and/or consumer uses unknown	--	--	--	--	277	1,362
Total	463,058	92,678	4,137	53,202	277	1,362

Shipments	Canadian Great Lakes commercial docks[3]	U.S. Great Lakes dock storage[3]	U.S. tide-water dock storage[3]	Over-seas exports[4]	Net change in mine invent-ory	Total
Total shipments to all destinations in the United States, Canada, and Mexico, by all methods of movement and consumer use, and overseas exports	41	-351	--	42,658	2,113	659,175
Shipments to all destinations in the United States, Canada, and Mexico by specific method of movement and consumer use:						
Method of movement:						
All-rail	--	--	--	--	--	331,048
River and ex-river	--	--	--	--	--	107,503
Great Lakes[1]	--	--	--	--	--	33,103
Tidewater[2]	--	--	--	--	--	5,344
Truck	--	--	--	--	--	69,410
Tramway, conveyor, private railroad	--	--	--	--	--	66,667
Method of movement and/or consumer uses unknown	41	-351	--	42,658	2,113	46,100
Total	41	-351	--	42,658	2,113	659,175

[1]Excludes shipments to Canadian Great Lakes commercial docks and U.S. dock storage for which consumer uses are not available; however, includes vessel fuel, the destinations of which are not available.
[2]Excludes overseas exports for which consumer uses are not available.
[3]Consumer use unknown.
[4]Excludes Canada; consumer use unknown.

Table 13.—Distribution of bituminous coal and lignite, in 1976, by district of origin and consumer use

(Thousand short tons)

District of origin[1]	Electric utilities	Coke and gas plants	Retail dealers	All others	Rail-road fuel	Used at mines and sales to employees
1	38,582	6,775	13	3,818	106	31
2	11,767	19,725	81	2,199	5	15
3 and 6	33,707	2,733	90	2,557	16	8
4	40,426	--	571	4,477	3	44
7	843	12,699	125	724	36	969
8	83,571	36,843	2,059	17,048	108	61
9	50,075	--	16	1,439	2	2
10	48,930	3,572	460	5,570	1	46
11	22,392	--	222	3,074	--	1
12	538	--	--	2	--	--
13	13,745	4,730	14	1,715	--	--
14	21	542	--	169	--	--
15	20,870	176	9	2,967	--	--
16	66	--	--	261	--	--
17	5,936	3,430	31	590	--	11
18	18,756	--	--	433	--	--
19	28,282	--	109	2,761	--	2
20	3,915	1,453	243	1,785	--	25
21	10,257	--	86	748	--	147
22 and 23	30,379	--	8	865	--	--
Total	463,058	92,678	4,137	53,202	277	1,362

District of origin[1]	Canadian Great Lakes commercial docks[2]	U.S. Great Lakes dock storage[2]	U.S. tide-water dock storage[2]	Over-seas exports[3]	Net change in mine inventory	Total
1	--	--	--	4,739	384	54,448
2	--	--	--	10	-51	33,751
3 and 6	22	-32	--	2,432	52	41,585
4	--	-44	--	--	333	45,810
7	9	--	--	11,563	-85	26,883
8	10	-272	--	20,737	521	160,686
9	--	-3	--	7	563	52,101
10	--	--	--	--	-53	58,526
11	--	--	--	--	-80	25,609
12	--	--	--	--	--	540
13	--	--	--	3,002	103	23,309
14	--	--	--	168	-6	894
15	--	--	--	--	41	24,063
16	--	--	--	--	--	327
17	--	--	--	--	41	10,039
18	--	--	--	--	-84	19,105
19	--	--	--	--	20	31,174
20	--	--	--	--	578	7,999
21	--	--	--	--	-5	11,233
22 and 23	--	--	--	--	-159	31,093
Total	41	-351	--	42,658	2,113	659,175

[1]Producing districts are defined in: Bureau of Mines Bituminous Coal and Lignite Distribution Calendar Year 1976, Mineral Industry Survey.
[2]Consumer use unknown.
[3]Excludes Canada; consumer use unknown.

Table 14.—Distribution of bituminous coal and lignite, in 1976, by destination and consumer use

(Thousand short tons)

Destination	Total	Electric utilities	Coke and gas plants	Retail dealers	All others[1]
New England:					
Massachusetts	71	--	--	9	62
Connecticut	19	4	--	--	15
Maine	21	--	--	1	20
New Hampshire	816	816	--	--	--
Vermont	1	--	--	--	1
Rhode Island	1	--	--	--	1
Total	929	820	--	10	99
Middle Atlantic:					
New York	13,562	5,980	5,157	20	2,405
New Jersey	2,497	2,484	--	--	13
Pennsylvania	64,592	37,249	23,281	192	3,870
Total	80,651	45,713	28,438	212	6,288
East North Central:					
Ohio	70,964	50,130	12,505	692	7,637
Indiana	45,837	29,239	12,450	363	3,785
Illinois	41,455	35,011	2,735	537	3,172
Michigan	29,805	21,197	4,493	248	3,867
Wisconsin	13,571	10,978	268	308	2,017
Total	201,632	146,555	32,451	2,148	20,478
West North Central:					
Minnesota	12,322	10,448	647	90	1,137
Iowa	7,894	6,547	--	35	1,312
Missouri	22,795	20,768	289	103	1,635
North Dakota	7,497	7,099	--	75	323
South Dakota	2,863	2,709	--	5	149
Nebraska	2,274	1,744	--	6	524
Kansas	3,482	3,404	--	--	78
Total	59,127	52,719	936	314	5,158
South Atlantic:					
Delaware	785	765	--	--	20
Maryland	9,190	4,693	4,309	9	179
District of Columbia	203	--	--	15	188
Virginia	7,470	5,307	8	254	1,901
West Virginia	36,480	28,115	5,295	110	2,960
North Carolina	21,231	19,886	--	168	1,177
South Carolina	6,753	5,509	--	85	1,159
Georgia	15,072	14,576	--	15	481
Florida	6,107	6,089	--	--	18
Total	103,291	84,940	9,612	656	8,083
East South Central:					
Kentucky	27,320	24,968	811	169	1,372
Tennessee	23,091	21,034	172	142	1,743
Alabama	25,982	17,856	6,691	7	1,428
Mississippi	1,671	1,572	--	--	99
Total	78,064	65,430	7,674	318	4,642
West South Central:					
Arkansas	145	--	--	--	145
Oklahoma	661	599	--	2	60
Texas	16,417	13,183	627	--	2,607
Total	17,223	13,782	627	2	2,812
Mountain:					
Colorado	9,201	7,570	1,110	31	490
Utah	4,487	1,805	1,968	121	593
Montana	2,565	2,452	--	5	108
Idaho	610	--	--	122	488
Wyoming	9,780	8,796	--	38	946
New Mexico	8,096	8,089	--	--	7
Arizona	7,070	6,754	--	--	316
Nevada	5,158	5,030	--	7	121
Total	46,967	40,496	3,078	324	3,069

See footnotes at end of table.

Table 14.—Distribution of bituminous coal and lignite, in 1976, by destination and consumer use —Continued

(Thousand short tons)

Destination	Total	Electric utilities	Coke and gas plants	Retail dealers	All others[1]
Pacific:					
Washington	4,677	4,087	--	13	577
Oregon	259	--	--	13	246
California	2,526	--	1,905	--	621
Total	7,462	4,087	1,905	26	1,444
Alaska	706	254	--	8	444
Canada[2]	16,466	8,212	7,697	105	452
Mexico	251	--	198	--	53
Destinations not revealable	232	50	62	14	106
Destinations and/or consumer uses not availble:					
Great Lakes movement:					
Canadian commercial docks	41	--	--	--	--
Vessel fuel	74	--	--	--	--
U.S. dock storage	-351	--	--	--	--
Tidewater movement:					
Overseas export (except Canada)	42,658	--	--	--	--
Bunker fuel	--	--	--	--	--
U.S. dock storage	--	--	--	--	--
Railroad fuel:					
U.S. companies	277	--	--	--	--
Canadian companies	--	--	--	--	--
Coal used at mines and sales to employees	1,362	--	--	--	--
Net change in mine inventory	2,113	--	--	--	--
Grand total	659,175	--	--	--	--

[1]Excludes vessel fuel and bunker fuel, the destinations of which are not available.
[2]Excludes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.

Table 15.—Total bituminous coal and lignite shipments and percent of grand total shipments, by geographic division and State of destination

Geographic division and State of destination	Thousand short tons					Percent of total				
	1972	1973	1974	1975	1976	1972	1973	1974	1975	1976
New England:										
Massachusetts	147	106	749	390	71	(1)	(1)	0.1	0.1	(1)
Connecticut	109	118	214	24	19	(1)	(1)	(1)	(1)	(1)
Maine, New Hampshire, Vermont, Rhode Island	1,266	1,109	1,092	1,098	839	0.2	0.2	.2	.2	0.1
Total	1,522	1,333	2,055	1,512	929	.2	.2	.3	.3	.1
Middle Atlantic:										
New York	13,177	13,290	14,742	11,844	13,562	2.2	2.3	2.4	1.8	2.0
New Jersey	1,303	2,524	3,058	2,368	2,497	.2	.4	.5	.4	.4
Pennsylvania	64,518	64,469	63,322	63,390	64,592	10.8	10.9	10.5	9.9	9.8
Total	78,998	80,283	81,122	77,602	80,651	13.2	13.6	13.4	12.1	12.2
East North Central:										
Ohio	67,795	65,557	69,642	68,019	70,964	11.4	11.1	11.5	10.6	10.8
Indiana	46,618	45,061	43,921	46,928	45,837	7.8	7.6	7.3	7.3	6.9
Illinois	42,028	40,628	39,054	41,948	41,455	7.1	6.9	6.5	6.6	6.3
Michigan	35,085	31,685	29,250	31,290	29,805	5.9	5.4	4.9	4.9	4.5
Wisconsin	14,978	12,634	12,335	14,075	13,571	2.5	2.2	2.0	2.2	2.1
Total	206,504	195,565	194,202	202,260	201,632	34.7	33.2	32.2	31.6	30.6
West North Central:										
Minnesota	8,639	9,161	9,668	11,033	12,322	1.4	1.6	1.6	1.7	1.9
Iowa	6,956	6,889	6,589	6,741	7,894	1.2	1.2	1.1	1.1	1.2
Missouri	15,810	17,385	17,844	19,741	22,795	2.7	2.9	3.0	3.1	3.4
North Dakota and South Dakota	5,834	5,816	6,254	7,850	10,360	1.0	1.0	1.0	1.2	1.6
Nebraska and Kansas	2,348	3,527	3,611	5,066	5,756	.4	.6	.6	.8	.9
Total	39,587	42,778	43,966	50,431	59,127	6.7	7.3	7.3	7.9	9.0
South Atlantic:										
Delaware and Maryland	9,744	10,596	9,691	8,855	9,975	1.6	1.8	1.6	1.4	1.5
District of Columbia	458	548	496	368	203	.1	.1	.1	(1)	(1)
Virginia	8,027	7,910	7,410	6,561	7,470	1.3	1.3	1.2	1.0	1.2
West Virginia	32,459	32,305	33,784	34,360	36,480	5.5	5.5	5.6	5.4	5.6
North Carolina	21,489	19,820	21,337	21,315	21,231	3.6	3.3	3.5	3.3	3.2
South Carolina	6,915	6,999	8,061	5,651	6,753	1.2	1.2	1.4	.9	1.0
Georgia and Florida	17,815	16,894	17,025	20,487	21,179	3.0	2.9	2.8	3.2	3.2
Total	96,907	95,072	97,804	97,597	103,291	16.3	16.1	16.2	15.2	15.7

See footnotes at end of table.

Table 15.—Total bituminous coal and lignite shipments and percent of grand total shipments, by geographic division and State of destination —Continued

Geographic division and State of destination	Thousand short tons					Percent of total				
	1972	1973	1974	1975	1976	1972	1973	1974	1975	1976
East South Central:										
Kentucky	27,389	25,078	25,445	28,480	27,320	4.6	4.2	4.2	4.4	4.2
Tennessee	21,390	22,238	18,916	26,633	23,091	3.6	3.8	3.2	4.2	3.5
Alabama and Mississippi	30,064	27,695	26,719	29,798	27,653	5.0	4.7	4.4	4.7	4.2
Total	78,843	75,011	71,080	84,911	78,064	13.2	12.7	11.8	13.3	11.9
West South Central:										
Arkansas, Louisiana, Oklahoma, Texas	930	8,049	8,894	12,423	17,223	.2	1.4	1.5	1.9	2.6
Mountain:										
Colorado	5,516	6,490	7,290	8,210	9,201	.9	1.1	1.2	1.3	1.4
Utah	3,017	3,957	4,252	4,514	4,487	.5	.7	.7	.7	.7
Montana and Idaho	1,281	1,395	1,379	1,763	3,175	.2	.2	.2	.3	.5
Wyoming	5,152	6,200	6,731	7,855	9,780	.9	1.1	1.1	1.2	1.5
New Mexico	6,851	7,343	7,686	7,422	8,096	1.1	1.2	1.3	1.2	1.2
Arizona and Nevada	4,513	4,451	7,634	8,497	12,228	.8	.8	1.3	1.3	1.8
Total	26,330	29,836	34,972	38,261	46,967	4.4	5.1	5.8	6.0	7.1
Pacific:										
Washington and Oregon	2,865	3,510	4,316	4,228	4,936	.5	.6	.7	.7	.7
California	1,780	2,398	2,184	2,136	2,526	.3	.4	.4	.3	.4
Total	4,645	5,908	6,500	6,364	7,462	.8	1.0	1.1	1.0	1.1
Alaska	707	707	690	768	706	.1	.1	.1	.1	.1
Canada[2]	18,162	16,231	13,706	16,735	16,507	3.1	2.7	2.3	2.6	2.5
Mexico	466	305	411	527	251	.1	.1	.1	.1	(1)
Destinations not revealable	[3]1,702	[4]1,755	408	307	232	[3].3	[4].3	.1	(1)	(1)
U.S. railroad fuel	357	224	256	278	277	.1	(1)	(1)	(1)	(1)
U.S. Great Lakes dock storage	-266	-117	228	134	-351	(1)	(1)	(1)	(1)	(1)
Vessel fuel	595	600	571	283	74	.1	.1	.1	(1)	(1)
Overseas exports	[5]36,607	[6]35,570	45,809	48,405	42,658	[5]6.1	[6]6.0	7.6	7.6	6.5

Coal used at mines and sales to employees	1,521	1,600	1,701	1,554	1,362	.2	.3	.2	.2	.2
Change in mine inventory	1,097	-922	-896	474	2,113	.2	-.2	-.1	.1	.3
Grand total	595,214	589,788	603,479	640,826	659,175	100.0	100.0	100.0	100.0	100.0

[1] Less than 0.1%.
[2] Includes shipments to Canadian Great Lakes commercial docks and railroad companies.
[3] Includes overseas exports from producing districts 13, 14, and 20.
[4] Includes overseas exports from producing districts 13 and 14.
[5] Excludes overseas exports from producing districts 13, 14, and 20.
[6] Excludes overseas exports from producing districts 13 and 14.

Table 16.—Exports of bituminous coal, by country group

(Thousand short tons and thousand dollars)

Country group	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada (including Newfoundland) and Mexico	14,117	356,384	17,262	676,773	16,748	717,498
Overseas (all other countries):						
West Indies and Central America	(1)	13	(1)	10	1	40
South America	2,350	97,285	3,274	191,550	2,912	160,919
Europe	15,856	633,601	18,972	909,755	20,026	933,522
Asia	27,603	1,333,050	25,943	1,444,077	19,271	1,054,295
Africa	(1)	(1)	218	10,728	448	20,193
Oceania	(1)	1	--	--	--	--
Total	45,809	2,063,950	48,407	2,556,120	42,658	2,168,969
Grand total	59,926	2,420,334	65,669	3,232,893	59,406	2,886,467

[1]Less than 1/2 unit.

Table 17.—Exports of bituminous coal, by country

(Thousand short tons and thousand dollars)

Country	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	630	28,796	930	55,833	526	30,111
Belgium-Luxembourg	1,109	48,259	627	33,986	2,202	91,763
Brazil	1,292	53,580	2,007	115,651	2,241	122,057
Canada	13,706	343,398	16,735	650,018	16,497	705,602
Chile	312	11,532	289	17,944	145	8,742
Denmark	--	--	--	--	34	839
Egypt	--	--	218	10,728	322	14,359
France	2,510	106,990	3,583	159,983	3,427	150,765
Germany, West	1,484	60,137	1,989	90,118	994	46,435
Greece	41	950	119	4,400	465	16,619
Israel	11	422	(1)	2	--	--
Italy	3,903	151,446	4,493	212,418	4,211	218,452
Japan	27,346	1,320,155	25,423	1,412,751	18,803	1,028,421
Korea, Republic of	246	12,464	319	21,048	468	25,872
Mexico	411	12,986	527	26,755	251	11,896
Netherlands	2,545	95,355	2,093	103,693	3,490	143,125
Norway	145	6,904	81	4,987	124	6,819
Peru	85	2,236	48	2,115	(1)	7
Portugal	334	14,347	246	14,391	258	13,548
Romania	163	5,528	343	17,521	212	10,735
South Africa, Republic of	--	--	--	--	126	5,833
Spain	2,017	87,768	2,691	149,279	2,513	126,167
Sweden	200	6,181	764	40,772	816	39,599
Switzerland	--	--	33	949	14	932
Turkey	--	--	201	10,263	239	11,224
United Kingdom	1,405	49,736	1,889	76,267	843	46,742
Uruguay	31	1,137	--	--	--	--
Yugoslavia	--	--	21	958	184	9,758
Other	(1)	27	(1)	63	1	45
Total	59,926	2,420,334	65,669	3,232,893	59,406	2,886,467

[1]Less than 1/2 unit.

Table 18.—Bituminous coal exported from the United States, by customs district

(Thousand short tons and thousand dollars)

Customs district	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
Baltimore	5,949	255,528	6,768	378,850	6,325	314,558
Buffalo	36	923	70	3,753	50	1,556
Charleston, S.C	(1)	(1)	--	--	(1)	2
Chicago	38	582	42	1,299	20	517
Cleveland	13,240	327,064	16,309	628,275	16,299	696,713
Detroit	136	4,660	122	6,031	81	3,805
Duluth	(1)	25	(1)	10	14	477
El Paso	24	500	50	1,413	38	1,344
Great Falls	--	--	--	--	(1)	7
Houston	(1)	3	--	--	--	--
Laredo	386	12,461	455	24,056	56	2,872
Los Angeles	115	4,174	(1)	9	(1)	2
Miami	--	--	--	--	1	15
Mobile	1,746	52,578	2,745	153,275	2,754	146,106
New Orleans	992	27,341	1,292	55,888	1,297	65,502
New York City	1	20	(1)	16	(1)	11
Nogales	--	--	(1)	4	--	--
Norfolk	35,745	1,648,712	36,953	1,929,963	32,003	1,626,475
Ogdensburg	24	650	25	1,175	15	885
Pembina	18	701	4	220	5	288
Philadelphia	1,431	83,461	803	47,423	448	25,301
Port Arthur	27	564	29	1,097	--	--
Portland, Maine	4	73	--	--	--	--
Portland, Oreg	13	253	--	--	--	--
San Diego	1	25	(1)	3	(1)	2
San Francisco	(1)	6	(1)	11	(1)	3
San Juan	(1)	5	(1)	4	--	--
Seattle	(1)	25	2	118	(1)	26
Total	59,926	2,420,334	65,669	3,232,893	59,406	2,886,467

[1]Less than 1/2 unit.

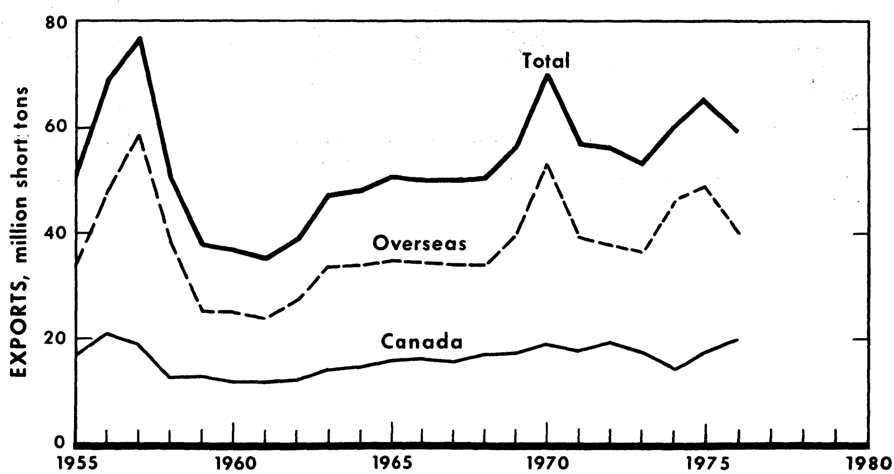

Figure 5.—Exports of bituminous coal and lignite from the United States to Canada and overseas.

Table 19.—Bituminous coal[1] imported for consumption in the United States, by country and customs district

Country and customs district	1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Country:						
Australia	143,633	$2,566	117,294	$2,109	--	--
Belgium-Luxembourg	1,135	60	--	--	--	--
Brazil	18	([2])	--	--	--	--
Canada	595,587	11,305	190,052	5,976	59,497	$1,166
France	764	94	1,821	300	--	--
Germany, West	513,219	24,432	88,369	5,073	320	26
Japan	--	--	12	1	44	2
Netherlands	171,185	7,817	--	--	--	--
New Zealand	--	--	--	--	6	([2])
Norway	1,654	139	--	--	--	--
Panama	1,128	15	--	--	--	--
Poland	468,344	7,040	171,703	2,581	361,649	7,529
Singapore	--	--	--	--	375	1
South Africa, Republic of	172,223	3,236	370,455	5,641	781,168	9,014
United Kingdom	11,517	1,027	--	--	--	--
Yugoslavia	--	--	15	1	17	1
Total	2,080,407	57,731	939,721	21,682	1,203,076	17,739
Customs district:						
Baltimore	622,824	17,659	115,820	5,858	7,716	157
Boston	666,954	11,000	319,624	5,140	--	--
Buffalo	1,005	47	20,532	707	836	20
Chicago	151	3	--	--	--	--
Cleveland	1,381	62	37,138	548	--	--
Detroit	101,866	1,597	2,307	35	225	7
Duluth	41,705	823	5,935	160	--	--
Great Falls	10,983	340	7,061	156	231	10
Los Angeles	--	--	112	11	1	([2])
Milwaukee	--	--	--	--	36,837	663
Mobile	117,246	1,842	370,581	6,313	781,168	9,014
New Orleans	13,189	1,166	--	--	194,658	4,157
New York City	--	--	70	6	219	11
Norfolk	--	--	--	--	80	16
Ogdensburg	--	--	792	11	754	10
Pembina	29,380	634	15,617	248	19,673	420
Philadelphia	470,521	22,495	33,882	2,389	439	2
Portland, Maine	3,202	63	1,619	33	384	23
Providence	--	--	8,560	65	--	--
San Francisco	--	--	--	--	6	([2])
Seattle	--	--	71	2	557	13
Tampa	--	--	--	--	159,292	3,216
Total	2,080,407	57,731	939,721	21,682	1,203,076	17,739

[1]Includes slack, culm, and lignite.
[2]Less than 1/2 unit.

Table 20.—Bituminous coal and lignite coal: World production, by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
North America:			
Canada:			
Bituminous	[r]19,604	23,932	22,799
Lignite	3,842	3,912	5,100
Mexico: Bituminous	5,694	5,725	6,228
United States:			
Bituminous	585,504	628,619	653,055
Lignite	15,496	19,819	25,630
South America:			
Argentina: Bituminous	690	554	678
Brazil: Bituminous (marketable)	[r]3,436	3,137	[e]3,200
Chile: Bituminous (marketable)	1,554	1,500	1,285
Colombia: Bituminous	3,472	[r] [e]3,500	[e]3,600
Peru: Bituminous	(2)	[r] [e](2)	[e](2)
Venezuela: Bituminous	63	66	98
Europe:			
Albania: Lignite[e] [3]	[r]940	[r]940	940
Austria: Lignite	4,001	3,745	3,543
Belgium: Bituminous	6,694	6,583	6,737
Bulgaria:			
Bituminous	209	234	[e]220
Lignite[3]	26,453	30,330	27,748
Czechoslovakia:			
Bituminous	[r]30,745	30,872	31,158
Lignite[3]	[r]91,260	95,996	98,628
France:			
Bituminous	18,650	18,801	18,814
Lignite	3,041	3,512	3,514
Germany, East:			
Bituminous	655	595	505
Lignite	268,368	271,821	272,140
Germany, West:			
Bituminous	96,443	93,412	91,096
Lignite	138,940	136,000	148,299
Greece: Lignite	[r]15,552	19,401	24,512
Hungary:			
Bituminous	3,537	3,329	3,235
Lignite[3]	24,859	24,104	24,606
Italy:			
Bituminous	4	2	1
Lignite	[r]2,160	2,274	2,235
Poland:			
Bituminous	178,579	189,185	197,646
Lignite	43,899	43,944	43,331
Romania:			
Bituminous[4]	[r]7,812	8,047	[e]7,780
Lignite[3]	[r]21,813	21,794	[e]21,730
Spain:			
Bituminous	[r]8,147	8,234	7,710
Lignite	[r]3,177	3,726	4,562
Svalbard (Spitzbergen): Bituminous[e] [5]	481	429	572
U.S.S.R.:[6]			
Bituminous	493,322	507,814	511,500
Lignite[3]	177,076	180,374	190,000
United Kingdom: Bituminous[7]	[r]118,681	139,050	[e]133,604
Yugoslavia:			
Bituminous	[r]662	659	646
Lignite[3]	[r]36,355	38,514	39,969
Africa:			
Algeria: Bituminous[8]	[r]14	9	3
Botswana: Bituminous	36	79	247
Mozambique: Bituminous	[r]469	634	[e]660
Nigeria: Bituminous	306	346	[e]350
Rhodesia, Southern: Bituminous[9]	[r]3,080	2,845	3,226
South Africa, Republic of: Bituminous (marketable)	71,232	74,791	82,233
Swaziland: Bituminous	[r]154	140	[10]170
Tanzania: Bituminous	2	1	[e]1
Zaire: Bituminous	105	98	110
Zambia: Bituminous	892	897	864
Asia:			
Afghanistan: Bituminous[11]	169	176	181
Burma: Bituminous	19	27	23
China, People's Republic of: Bituminous and lignite[e]	475,000	495,000	510,000
India:			
Bituminous	92,706	105,746	111,324
Lignite	3,355	3,111	4,260
Indonesia: Bituminous	172	228	202
Iran: Bituminous	1,323	1,100	1,100

See footnotes at end of table.

Table 20.—Bituminous coal and lignite coal: World production, by country —Continued

(Thousand short tons)

Country[1]	1974	1975	1976[p]
Asia —Continued			
Japan:			
Bituminous	[r]22,259	20,841	20,237
Lignite	83	67	58
Korea, North: Bituminous[e 12]	8,700	8,800	8,800
Mongolia:			
Bituminous	151	188	220
Lignite	2,576	2,810	2,921
Pakistan: Bituminous and lignite[13]	1,653	1,173	1,213
Philippines: Bituminous	56	116	123
Taiwan: Bituminous	3,235	3,462	3,567
Thailand: Lignite	534	510	750
Turkey:[10]			
Bituminous	[r]5,185	5,055	4,295
Lignite	[r]5,933	6,763	6,411
Oceania:			
Australia:			
Bituminous	[r]69,482	73,788	[e]76,000
Lignite	[r]30,096	31,060	34,104
New Zealand:			
Bituminous	[r]2,668	2,509	2,554
Lignite	[r]158	150	187
World total:			
Bituminous	[r]1,867,053	1,976,155	2,018,657
Lignite	[r]919,967	944,677	985,178
Mixed grades	476,653	496,173	511,213
Total, all grades	[r]3,263,673	3,417,005	3,515,048

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, Ecuador produces coal, but output was less than 500 tons annually in the years covered by this table.

[2]Less than 1/2 unit.

[3]Includes material reported in national sources as brown coal.

[4]Official sources report the aggregate of bituminous coal and anthracite; distribution to these separate grades is estimated from reported total.

[5]Output from Norwegian controlled portion only. Output of that portion of Svalbard controlled by the U.S.S.R. is presumably included in the total output recorded for that country. The U.S.S.R. output in short tons was as follows: 1974, 540,000; 1975, 440,000; 1976, 440,000.

[6]Run-of-mine output.

[7]Includes slurry.

[8]May include a small amount of anthracite.

[9]Sales for year ending August 31 of that stated.

[10]Sales.

[11]Year beginning March 21 of that stated.

[12]Data include low-ranked coals, including some lignite.

[13]Year ending June 30 of that stated.

Coal—Pennsylvania Anthracite

By L. W. Westerstrom[1] and W. M. Watson[2]

All of the reported output of anthracite in 1976 was produced in northeastern Pennsylvania. The anthracite region is divided geologically into four fields: Eastern Middle, Northern, Southern and Western Middle. The area is also grouped into three trade regions: Lehigh, Schuylkill, and Wyoming.

The total production in 1976 was 6.2 million short tons, a 0.4% increase over the amount produced in 1975. Of the total output, 48% was produced at strip pits, 41% was recovered from culm banks, 9% was produced at underground mines, and approximately 2% was recovered from river dredging operations. In comparing 1976 with 1975, there were increases of 17.0% in production from strip mines and 15.8% in the recovery of river coal. There were decreases of 12.5% in culm recovery and 8.9% in production from underground mines.

The total value of the 1976 output was $209.2 million, a 5.4% increase over the 1975 value. The average commercial value, f.o.b. preparation plants for all sizes, increased $1.67 per ton (from $45.04 to $46.71), and the average value of buckwheat No. 1 and smaller sizes increased $1.50 per ton (from $27.61 to $29.11).

Apparent consumption of Pennsylvania anthracite in the United States in 1976, calculated as production minus exports (including that exported to West Germany for use by the U.S. Armed Forces), totaled approximately 5.0 million tons, a decline of 1.3% from the 5.1 million tons consumed in 1975.

Exports of anthracite (as reported to the U.S. Bureau of the Census) totaled 615,167 tons for 1976, a decrease of 3.8% from the amount exported in 1975. However, when the quantity shipped for use by the U.S. Armed Forces in West Germany is added to the tonnage reported by the Bureau of the Census, the actual tonnage exported is 1,188,234 tons, an increase of 8.5% from the comparable amount shipped in 1975.

The Pennsylvania anthracite mining industry worked an average of 235 days in 1976 and employed a work force of 3,686. Of that total, 742 were employed at underground mines, 1,375 at strip operations, 328 in recovering coal from culm banks, 15 in dredging operations, and 1,226 at preparation plants and other surface operations. In operation were 122 underground mines, 112 strip pits, 117 culm banks, 6 dredges, and 91 preparation plants.

Productivity in the anthracite industry declined in 1976. The average output per man per day declined from 7.45 tons in 1975 to 7.19 tons in 1976. There was one fatality in 1975 and one in 1976. Nonfatal injuries increased from 351 in 1975 to 374 in 1976.

Legislation and Government Programs.—State and Federal Government public works-type programs in the environmental area continued throughout 1976 and included control and extinguishment of fires from abandoned underground mines, reclamation of old strip pits and culm banks, and extinguishment of burning coal mine refuse banks. In addition, mine-water control projects were designed to secure the safety and livelihood of mine personnel and to protect anthracite reserves from the hazards of adjoining abandoned mine pools and possible inundatation by surface flood waters.

Hydrologic studies continue to evaluate

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mine-water problems. They involve determination of the varying heights of underground mine pools, their hydrostatic pressures, and their possible effect on barrier pillars and mine dams protecting active mining operations, and acid mine-water drainage into surface streams and the unconsolidated valley fill. Under the closely related mine-water control program, a comprehensive series of mine pool monitoring stations have been installed, and additional phases of the project are proceeding in the Western, Middle, and Southern fields.

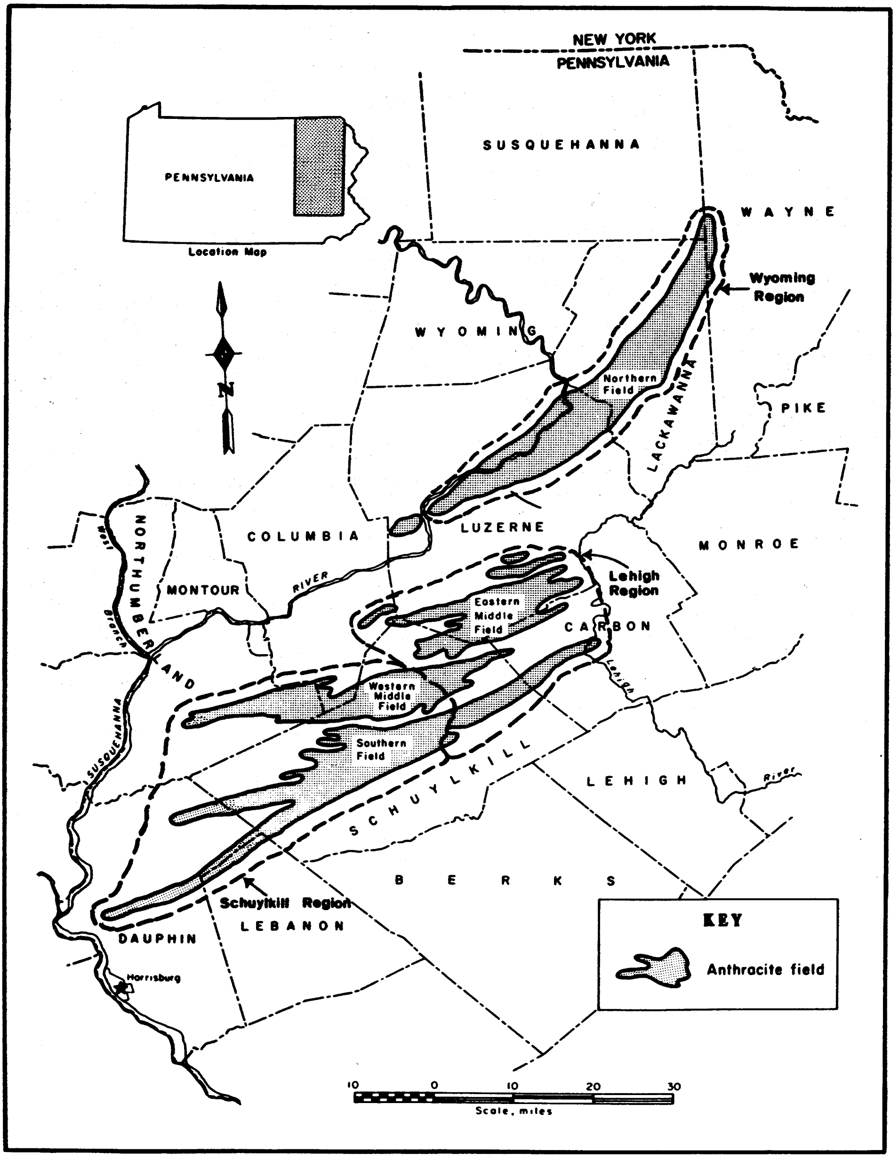

Figure 1.—Coalfields, regions, and counties of the Pennsylvania anthracite area.

FOREIGN TRADE

According to data released by the U.S. Bureau of the Census, 615,167 short tons of Pennsylvania anthracite was exported in 1976, a decrease of 3.8% from that shipped in 1975. Of the total, 72.4% was exported to Canada, a decrease of 18.1% from the amount shipped in 1975; 3.1% to South America; 0.2% to Asia; and the remainder to other countries. The Census Bureau figures do not include anthracite shipped abroad for the use of the U.S. Armed Forces in West Germany; therefore, a more complete measurement of exports can be obtained by adding the military tonnage (573,067) to the tonnage reported by the Bureau of the Census. Consequently, 1,188,234 short tons was exported in 1976.

Table 1.—Salient statistics of the Pennsylvania anthracite industry

	1972	1973	1974	1975	1976
Production:					
Preparation plants short tons	6,618,205	6,377,512	6,454,385	6,117,156	6,127,884
Dredges do	476,792	441,076	150,468	76,142	87,942
Used at collieries for power and heat do	11,298	11,373	12,013	10,012	12,407
Total production do	7,106,295	6,829,961	6,616,866	6,203,310	6,228,233
Value thousands	$85,251	$90,260	$144,695	$198,481	$209,234
Average sales realization per short ton on preparation-plant shipments (excludes dredge coal):					
Pea and larger	$17.18	$18.76	$30.41	$45.04	$46.71
Buckwheat No. 1 and smaller	$10.14	$11.30	$18.88	$27.61	$29.11
All sizes	$12.40	$13.65	$22.19	$32.26	$33.92
Percentage of total preparation-plant shipment (excludes dredge coal):					
Pea and larger	32.0	31.4	28.8	26.7	27.3
Buckwheat No. 1 and smaller	68.0	68.6	71.2	73.3	72.7
Exports[1] short tons	743,451	716,546	735,173	639,601	615,167
Consumption, apparent[2] do	5,915,000	5,671,000	5,448,000	5,108,000	5,040,000
Average number of days worked	216	234	219	214	235
Average number of men working daily	4,783	4,083	3,847	3,907	3,686
Output per man per day short tons	6.88	7.15	7.87	7.45	7.19
Output per man per year do	1,486	1,673	1,720	1,594	1,697
Quantity mined by stripping do	3,483,076	3,278,977	2,868,783	2,563,701	2,999,584
Quantity loaded by machines underground do	593,997	421,202	307,475	298,944	284,538
Distribution:					
Exports to Canada[1] do	500,306	477,692	481,345	543,552	445,397
Loaded into vessels at Lake Erie[3] do	39,177	19,244	22,965	12,476	4,936

[1]U.S. Department of Commerce; 1972-76 export data do not include shipments to U.S. Military Forces.
[2]Excludes shipments to U.S. Armed Forces.
[3]Ore and Coal Exchange, Cleveland, Ohio.

Table 2.—Standard anthracite specifications approved and adopted by the Anthracite Committee, effective July 28, 1947, and amended July 20, 1953

Size	Round test mesh (inches)	Percent: Undersize Maximum	Percent: Undersize Minimum	Percent: Maximum impurities[1] Slate	Percent: Maximum impurities[1] Bone	Percent: Maximum impurities[1] Ash[2]
Broken	Through 4 3/8	--	--	1 1/2	2	11
	Over 3 1/4 to 3	15	7 1/2	--	--	--
Egg	Through 3 1/4 to 3	--	--	1 1/2	2	11
	Over 2 7/16	15	7 1/2	--	3	11
Stove	Through 2 7/16	--	--	2	3	11
	Over 1 5/8	15	7 1/2	--	--	--
Chestnut	Through 1 5/8	--	--	3	4	11
	Over 13/16	15	7 1/2	--	--	--
Pea	Through 13/16	--	--	4	5	12
	Over 9/16	15	7 1/2	--	--	--
Buckwheat No. 1	Through 9/16	--	--	--	--	13
	Over 5/16	15	7 1/2	--	--	--
Buckwheat No. 2 (rice)	Through 5/16	--	--	--	--	13
	Over 3/16	17	7 1/2	--	--	--
Buckwheat No. 3 (barley)	Through 3/16	--	--	--	--	15
	Over 3/32	20	10	--	--	--
Buckwheat No. 4	Through 3/32	--	--	--	--	15
	Over 3/64	30	10	--	--	--
Buckwheat No. 5	Through 3/64	NL	NL	--	--	16

NL No limit.
[1]When slate content in sizes from broken to chestnut, inclusive, is less than above standards, bone content may be increased by 1 1/2 times the decrease in slate content under the allowable limits, but slate content specified above shall not be exceeded in any event. A tolerance of 1% is allowed on maximum percentage of undersize and maximum percentage of ash content. Maximum percentage of undersize is applicable only to anthracite as it is produced at preparation plant. Slate is defined as any material that has less than 40% fixed carbon. Bone is defined as any material that has 40% or more, but less than 75%, fixed carbon.
[2]Ash determinations are on a dry basis.

Table 3.—Project report

Project location	Project description	Sponsor	Status of report
	ACID COAL MINE DRAINAGE		
Anthracite fields	Monthly measurements of mine water levels and overflows.	U.S. Geological Survey and Federal Bureau of Mines.	Continuous.
Carbon, Dauphin, and Schuylkill Counties.	Mine Drainage Project No. 46, Phase E.	Federal Bureau of Mines and Commonwealth of Pennsylvania.	Work in progress 1976.
	SURFACE SUBSIDENCE		
Lackawanna County:			
Archbald Borough	Pumped Slurry Mine Backfilling Demonstration Project.	Federal Bureau of Mines.	Work started 1976.
Dickson City	Subsidence control, backfilling	do	Work in progress 1976.
Jessup Borough	Pumped Slurry Mine Backfilling Demonstration Project.	do	Work started 1976.
Moosic Borough	Subsidence Control	Federal Bureau of Mines and Commonwealth of Pennsylvania.	Do.
Olyphant Borough	Demonstration project for hydraulic backfilling into inaccessible mine voids to establish limitations in the use of the pumped slurry.	Federal Bureau of Mines.	Work completed 1976.
Scranton:			
Hill section	Sudsidence Control Project No. 12, Phases 1 and 2.	Federal Bureau of Mines and Commonwealth of Pennsylvania.	Work in progress 1976.
Minooka section	Filling mine voids. Blind-flushing approximately 17 acres of a Pilot Demonstration Project.	do	Work completed 1976.
Southside section	Hydraulic flushing of mine voids, Project No. 11.	do	Do.
Taylor	Subsidence control, backfilling	Federal Bureau of Mines.	Do.
Luzerne County:			
Borough of Swoyersville	Subsidence Control Project No. 15	Federal Bureau of Mines and Commonwealth of Pennsylvania.	Work started in 1976.
Pittston	Subsidence control	do	Work in progress 1976.
Plymouth Borough	Subsidence Control Project No. 16	do	Work started 1976.
	SURFACE MINE RECLAMATION PROJECTS		
Luzerne County:			
Nanticoke	Surface Mine Reclamation Project No. 13.	Federal Bureau of Mines and Commonwealth of Pennsylvania.	Work started and completed in 1976.

Table 4.—Summary of monthly developments in the Pennsylvania anthracite industry in 1976

(Thousand short tons, except as otherwise indicated)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year 1976	Change from 1975 (percent)	Year 1975
Production (including mine fuel, local sales, dredge coal)	525	440	525	520	555	610	490	590	515	490	493	475	6,228	+0.4	6,203
Shipments (breakers and washeries only, all sizes):															
By rail[1]	96	116	168	166	165	243	144	195	189	179	119	149	1,929	-6.9	2,073
By truck[2]	322	291	309	272	270	294	255	304	302	321	336	350	3,626	+.7	3,600
Carloadings[3]	1	2	3	3	3	4	3	4	4	3	2	3	35	+9.4	32
Distribution:															
Lake Erie loadings[4]	--	--	--	--	2	--	--	--	--	--	3	--	5	-58.3	12
Upper Lake dock trade:[5]															
Receipts	(6)	--	--	--	--	--	--	(6)	--	(6)	(6)	(6)	1	-50.0	2
Deliveries (reloadings)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	--	--	1
Exports[7]	14	24	21	66	80	75	47	47	120	42	56	23	615	-3.9	640
Industrial consumption and stocks by—															
Electrical utilities:[8]															
Consumption	113	97	103	121	128	123	126	131	107	91	94	116	1,350	-8.9	1,482
Stocks	967	961	974	981	997	1,005	1,027	1,021	1,036	1,062	1,042	1,000	1,000	+1.8	982
Coke plants:															
Used for carbonizing	28	28	34	34	31	32	33	31	32	30	33	34	380	+15.9	328
Stocks	114	89	77	84	85	81	83	91	93	101	107	98	98	-22.2	126
Stocks on Upper Lake docks:[5]															
Lake Michigan	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	--	(6)	(6)	(6)	(6)	--	(6)
Stocks in retail dealer yards:[9]															
Pea and larger	24	22	21	20	23	27	25	26	27	25	22	21	21	-56.3	48
Buckwheat No. 1 and smaller	8	8	8	7	9	9	9	11	11	11	12	12	12	+9.1	11
Total	32	30	29	27	32	36	34	37	38	36	34	33	33	-44.1	59

Retail dealer deliveries:[9]															
Pea and larger	21	14	9	5	5	5	5	7	12	18	19	21	141	-66.4	420
Buckwheat No. 1 and smaller	97	59	37	28	32	21	40	28	27	41	42	42	494	-21.6	630
Total	118	73	46	33	37	26	45	35	39	59	61	63	635	-39.5	1,050
Wholesale price indexes (1967=100) f.o.b. car at mines:[10]															
Pea and larger	355.0	355.0	355.0	355.0	355.0	355.0	355.0	355.0	355.0	355.0	355.0	355.0	355.0	+3.0	344.7
Buckwheat No. 1 and smaller	440.1	440.1	440.1	440.1	440.1	440.1	440.1	440.1	427.5	427.5	427.5	427.5	435.9	+5.5	413.3

[1]Furnished by initial carriers.
[2]Pennsylvania Department of Environmental Resources.
[3]Association of American Railroads.
[4]Ore and Coal Exchange, Cleveland, Ohio.
[5]Data furnished by Lake dock operators.
[6]Less than 1/2 unit.
[7]U.S. Department of Commerce. Does not include shipments to the U.S. Military Forces.
[8]Federal Power Commission.
[9]Estimated from reports submitted by a selected list of retail dealers located outside the producing region.
[10]Furnished by the Bureau of Labor Statistics from data obtained from authorized trade publications.

NOTE: According to the Association of American Railroads, 657,052 short tons of anthracite were exported to Europe during 1976, compared with 582,185 short tons for 1975. Of this total 573,586 short tons were consigned to West Germany and the Netherlands, including exports to the U.S. Military Forces. This compares with 510,577 short tons for 1975.

Table 5.—Commercial production of Pennsylvania anthracite in 1976, by region and size

Size	From preparation plants												From river dredging			Total[2]		
	Lehigh region			Schuylkill region			Wyoming region[1]			Total[2]								
	Rail	Truck	Total[2]	Rail	Truck	Total[2]	Rail	Truck	Total[2]	Rail	Truck	Total	Rail	Truck	Total[2]	Rail	Truck	Total
Quantity, thousand short tons:																		
Egg	60	5	65	([3])	1	1	5	17	22	65	23	88	--	--	--	65	23	88
Stove	203	31	234	194	130	324	4	19	23	401	180	581	--	--	--	401	180	581
Chestnut	108	111	219	118	215	332	5	39	45	231	365	596	--	--	--	231	365	596
Pea	45	98	142	60	160	220	4	42	46	108	300	408	--	--	--	108	300	408
Total pea and larger[2]	416	244	661	371	506	877	18	118	136	806	868	1,673	--	--	--	806	868	1,673
Buckwheat No. 1	144	87	231	96	193	289	8	51	59	248	331	580	--	--	--	248	331	580
Buckwheat No. 2 (rice)	45	140	185	33	264	297	4	65	69	81	470	551	--	--	--	81	470	551
Buckwheat No. 3 (barley)	102	84	186	77	245	322	9	103	113	188	432	620	--	--	--	188	432	620
Buckwheat No. 4	48	39	87	140	168	308	16	40	56	204	247	451	--	5	5	204	252	456
Buckwheat No. 5	95	58	153	222	195	417	75	20	95	392	273	665	--	--	--	392	273	665
Other[4]	16	148	163	19	1,042	1,061	22	342	364	56	1,531	1,588	4	78	83	61	1,610	1,671
Total buckwheat No. 1 and smaller	449	556	1,005	587	2,107	2,694	134	621	755	1,170	3,284	4,455	4	84	88	1,175	3,368	4,543
Grand total[2]	866	800	1,666	958	2,613	3,571	152	739	891	1,976	4,152	6,128	4	84	88	1,980	4,236	6,216
Value, thousands:																		
Egg	3,014	261	3,275	10	56	65	224	763	987	3,247	1,080	4,327	--	--	--	3,247	1,080	4,327
Stove	10,385	1,588	11,973	9,453	6,110	15,564	185	867	1,052	20,023	8,566	28,589	--	--	--	20,023	8,566	28,589
Chestnut	5,148	5,408	10,556	5,663	9,908	15,572	242	1,729	1,970	11,053	17,045	28,099	--	--	--	11,053	17,045	28,099
Pea	1,853	4,158	6,011	2,686	6,642	9,328	151	1,656	1,806	4,689	12,456	17,145	--	--	--	4,689	12,456	17,145
Total pea and larger[2]	20,399	11,416	31,815	17,813	22,716	40,529	801	5,015	5,816	39,013	39,147	78,160	--	--	--	39,013	39,147	78,160

Buckwheat No. 1	6,646	4,025	10,671	4,233	7,768	12,000	311	1,964	2,275	11,189	13,757	24,946	--	--	--	11,189	13,757	24,946
Buckwheat No. 2 (rice)	1,892	6,190	8,081	1,410	10,595	12,005	149	2,457	2,606	3,451	19,241	22,692	--	--	--	3,451	19,241	22,692
Buckwheat No. 3 (barley)	4,403	3,382	7,784	3,414	9,725	13,139	385	3,198	3,583	8,202	16,305	24,507	--	--	--	8,202	16,305	24,507
Buckwheat No. 4	2,009	1,542	3,551	5,948	4,710	10,658	608	1,274	1,882	8,565	7,526	16,091	--	52	52	8,565	7,578	16,143
Buckwheat No. 5	3,151	1,713	4,864	6,583	4,353	10,936	2,467	559	3,026	12,201	6,624	18,825	--	--	--	12,201	6,624	18,825
Other[4]	225	2,066	2,291	385	14,012	14,397	437	5,492	5,929	1,047	21,570	22,617	43	784	827	1,089	22,354	23,443
Total buckwheat No. 1 and smaller[2]	18,324	18,918	37,243	21,973	51,162	73,135	4,357	14,943	19,300	44,654	85,023	129,678	43	836	879	44,697	85,860	130,557
Grand total	38,723	30,334	69,058	39,785	73,878	113,664	5,158	19,958	25,116	83,667	124,170	207,838	43	836	879	83,709	125,006	208,717
Average value per ton:[5]																		
Egg	$50.26	$52.66	$50.45	$48.28	$47.80	$47.87	$45.00	$45.15	$45.12	$49.86	$46.90	$49.08	--	--	--	49.86	46.90	49.08
Stove	51.07	51.61	51.14	48.81	47.06	48.11	45.00	45.22	45.18	49.92	47.64	49.21	--	--	--	49.92	47.64	49.21
Chestnut	47.65	48.67	48.17	48.18	46.13	46.86	44.66	43.96	44.05	47.85	46.67	47.13	--	--	--	47.85	46.67	47.13
Pea	41.35	42.63	42.22	44.98	41.56	42.49	39.85	39.13	39.19	43.30	41.56	42.02	--	--	--	43.30	41.56	42.02
Total pea and larger	49.02	46.71	48.17	47.99	44.93	46.23	43.83	42.60	42.77	48.43	45.11	46.71	--	--	--	48.43	45.11	46.71
Buckwheat No. 1	46.11	46.22	46.15	44.12	40.18	41.49	37.58	38.52	38.39	45.06	41.51	43.03	--	--	--	45.06	41.51	43.03
Buckwheat No. 2 (rice)	42.38	44.13	43.71	42.89	40.07	40.38	39.78	37.88	37.98	42.47	40.98	41.20	--	--	--	42.47	40.98	41.20
Buckwheat No. 3 (barley)	43.16	40.36	41.90	44.34	39.76	40.86	41.47	30.98	31.85	43.56	37.78	39.53	--	--	--	43.56	37.78	39.53
Buckwheat No. 4	41.67	39.71	40.79	42.50	27.99	34.58	37.98	32.13	33.81	41.95	30.50	35.68	--	9.90	9.90	41.95	30.07	35.38
Buckwheat No. 5	33.27	29.35	31.77	29.60	22.34	26.21	32.96	27.69	31.84	31.13	24.23	28.30	--	--	--	31.13	24.23	28.30
Other[4]	14.23	14.00	14.02	20.46	13.45	13.57	20.01	16.06	16.29	18.54	14.08	14.24	10.00	10.00	10.00	17.94	13.89	14.03
Total buckwheat No. 1 and smaller	40.77	34.03	37.04	37.44	24.28	27.14	32.51	24.07	25.57	38.15	25.89	29.11	10.00	9.99	9.99	38.05	25.49	28.74
Grand total	44.74	37.90	41.45	41.53	28.27	31.83	33.87	27.02	28.19	42.34	29.91	33.92	10.00	9.99	9.99	42.27	29.51	33.58

[1]Includes Sullivan County.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1,000 short tons.
[4]Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[5]Average value derived from actual rather than rounded data.

Table 6.—Sizes of Pennsylvania anthracite (excluding dredge coal) prepared at plants, by region

(Percent)

Size	1972	1973	1974	1975	1976	1972	1973	1974	1975	1976
	Lehigh region					Schuylkill region				
Lump[1] and broken	--	--	--	--	--	--	--	--	--	--
Egg	2.4	4.6	5.4	5.7	3.9	0.3	0.3	0.1	(2)	(2)
Stove	10.8	12.9	14.4	12.3	14.1	10.2	9.1	7.6	8.5	9.1
Chestnut	10.6	9.9	12.8	11.4	13.2	10.1	9.4	8.6	9.6	9.3
Pea	8.5	8.5	9.9	6.3	8.5	6.9	6.8	6.5	7.0	6.2
Total pea and larger	32.3	35.9	42.5	35.7	39.7	27.5	25.6	22.8	25.2	24.6
Buckwheat No. 1	12.1	11.3	12.1	10.3	13.9	9.0	8.7	7.5	8.8	8.1
Buckwheat No. 2 (rice)	9.0	9.0	11.3	8.6	11.1	8.8	8.3	7.5	8.3	8.3
Buckwheat No. 3 (barley)	9.1	9.4	11.1	9.1	11.2	12.2	11.2	10.2	11.8	9.0
Buckwheat No. 4	5.9	5.6	5.9	4.8	5.2	10.3	8.5	7.3	7.6	8.6
Buckwheat No. 5	14.5	14.5	16.0	10.7	9.2	22.0	20.4	20.3	15.4	11.7
Other[3]	17.1	14.3	1.1	20.8	9.7	10.2	17.3	24.4	22.9	29.7
Total buckwheat No. 1 and smaller	67.7	64.1	57.5	64.3	60.3	72.5	74.4	77.2	74.8	75.4
	Wyoming region					Total				
Lump[1] and broken	--	--	--	--	--	--	--	--	--	--
Egg	1.7	2.1	1.9	1.6	2.5	1.1	1.7	1.6	1.9	1.4
Stove	13.6	14.1	6.8	3.0	2.6	11.0	11.0	9.3	8.8	9.5
Chestnut	15.6	13.8	14.0	4.6	5.0	11.4	10.2	10.3	9.4	9.7
Pea	12.9	14.4	8.3	5.4	5.2	8.5	8.5	7.6	6.6	6.7
Total pea and larger	43.8	44.4	31.0	14.6	15.3	32.0	31.4	28.8	26.7	27.3
Buckwheat No. 1	16.4	15.9	7.8	10.3	6.7	11.2	10.7	8.7	9.5	9.5
Buckwheat No. 2 (rice)	9.8	9.1	5.5	9.5	7.7	9.1	8.6	8.2	8.5	9.0
Buckwheat No. 3 (barley)	11.5	13.1	11.8	13.2	12.6	11.3	11.0	10.6	11.2	10.1
Buckwheat No. 4	4.4	5.4	10.3	7.2	6.2	8.0	7.2	7.2	6.8	7.4
Buckwheat No. 5	2.5	2.7	1.2	3.5	10.7	16.1	15.9	17.2	12.3	10.8
Other[3]	11.6	9.4	32.4	41.7	40.8	12.3	15.2	19.3	25.0	25.9
Total buckwheat No. 1 and smaller	56.2	55.6	69.0	85.4	84.7	68.0	68.6	71.2	73.3	72.7

[1]Quantity of lump included is insignificant.
[2]Less than 0.05 %.
[3]Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.

Table 7.—Production of Pennsylvania anthracite in 1976, by region and county

(Thousand short tons and thousand dollars)

Source	Rail shipments: Quantity	Rail shipments: Value[2]	Truck shipments: Quantity	Truck shipments: Value[2]	Colliery fuel: Quantity	Colliery fuel: Value	Total production[1]: Quantity	Total production[1]: Value[2]
REGION								
Lehigh: Preparation plants	866	38,723	800	30,334	5	234	1,671	69,292
Schuylkill:								
Preparation plants	958	39,785	2,613	73,878	7	263	3,578	113,927
Dredges	4	43	84	836	--	--	88	879
Total Schuylkill[1]	962	39,828	2,697	74,714	7	263	3,666	114,806
Wyoming: Preparation plants[3]	152	5,158	739	19,958	(4)	20	891	25,136
Total:[1]								
Preparation plants	1,976	83,666	4,152	124,170	12	517	6,141	208,355
Dredges	4	43	84	836	--	--	88	879
Grand total[1]	1,980	83,710	4,236	125,007	12	517	6,228	209,234

See footnotes at end of table.

Table 7.—Production of Pennsylvania anthracite in 1976, by region and county —Continued

(Thousand short tons and thousand dollars)

Source	Rail shipments		Truck shipments		Colliery fuel		Total production[1]	
	Quantity	Value[2]	Quantity	Value[2]	Quantity	Value	Quantity	Value[2]
COUNTY								
Berks and Snyder	4	43	71	735	--	--	75	777
Carbon	16	218	284	7,365	--	--	300	7,584
Columbia	--	--	101	3,644	--	--	101	3,644
Dauphin	--	--	61	1,244	--	--	61	1,244
Lackawanna	14	437	200	5,599	(4)	8	214	6,043
Luzerne	667	28,534	881	30,777	6	247	1,554	59,557
Northumberland	200	6,746	691	17,974	(4)	35	892	24,756
Schuylkill	1,079	47,732	1,888	56,109	6	228	2,973	104,069
Sullivan	--	--	58	1,560	--	--	58	1,560
Total[1]	1,980	83,710	4,236	125,007	12	517	6,228	209,234

[1]Data may not add to totals shown because of independent rounding.
[2]Value given for shipments is that at which coal left possession of producing company; does not include selling expenses.
[3]Includes Sullivan County.
[4]Less than 1,000 short tons.

Table 8.—Pennsylvania anthracite produced, by field

(Thousand short tons)

Field	1972	1973	1974	1975	1976
Eastern Middle: Breakers and washeries	1,221	1,288	1,156	1,170	962
Western Middle:					
Breakers and washeries	1,741	1,663	1,939	1,451	1,653
Dredges	W	W	W	W	W
Total	W	W	W	W	W
Southern:					
Breakers and washeries	2,333	2,427	2,693	2,602	2,633
Dredges	W	W	W	W	W
Total	W	W	W	W	W
Northern: Breakers and washeries[1]	1,334	1,011	677	905	891
Total:					
Breakers and washeries	6,629	6,389	6,466	6,127	6,140
Dredges	477	441	150	76	88
Grand total[2]	7,106	6,830	6,617	6,203	6,228

W Withheld to avoid disclosing individual company confidential data.
[1]Includes Sullivan County.
[2]Data may not add to totals shown because of independent rounding.

Table 9.—Pennsylvania anthracite produced in 1976, classified as fresh-mined, culm-bank, and river coal, by field and region

(Thousand short tons)

Source	Fresh-mined coal: Underground mines: Mechanically loaded	Hand loaded	Total[1]	Strip pits	From culm banks	From river dredging	Total[1]
FIELD							
Eastern Middle	--	--	--	871	91	--	962
Western Middle	46	76	122	513	1,018	W	W
Southern	238	224	462	1,369	802	W	W
Northern[2]	--	--	--	246	646	--	891
Total[1]	285	299	584	2,999	2,557	88	6,228
REGION							
Lehigh	--	--	--	1,240	430	--	1,671
Schuylkill	285	299	584	1,513	1,481	88	3,666
Wyoming	--	--	--	246	646	--	892
Total[1]	285	299	584	2,999	2,557	88	6,228

W Withheld to avoid disclosing individual company confidential data.
[1]Data may not add to totals shown because of independent rounding.
[2]Includes Sullivan County.

Table 10.—Production of Pennsylvania anthracite from strip pits

	Mined by stripping (thousand short tons)	Percent of fresh-mined total	Number of men employed	Average number of days worked
1972	3,483	78.7	2,011	261
1973	3,279	81.9	1,633	250
1974	2,869	81.4	1,376	244
1975	2,564	79.9	1,468	213
1976:				
Lehigh region	1,240	34.6	NA	NA
Schuylkill region	1,513	42.2	NA	NA
Wyoming region[1]	246	6.9	NA	NA
Total or average	2,999	83.7	1,375	235

NA Not available.
[1]Includes Sullivan County.

Table 11.—Power shovels, front-end loaders, and draglines used in recovering coal from culm banks and stripping Pennsylvania anthracite, by type of power

Type of power	1974				1975				1976			
	Front-end loaders	Power shovels	Draglines	Total	Front-end loaders	Power shovels	Draglines	Total	Front-end loaders	Power shovels	Draglines	Total
Gasoline	--	2	2	4	--	4	1	5	--	1	1	2
Electric	--	14	30	44	--	13	27	40	--	9	30	39
Diesel	146	27	73	246	179	38	98	315	215	45	104	364
Diesel-electric	--	--	--	--	--	1	1	2	--	1	1	2
Total	146	43	105	294	179	56	127	362	215	56	136	407

Table 12.—Production of Pennsylvania anthracite from culm banks, by region

(Thousand short tons)

Year	Lehigh region	Schuylkill region	Wyoming region	Total
1972	614	1,411	177	2,202
1973	611	1,612	161	2,384
1974	468	2,037	435	2,940
1975	720	1,492	710	2,922
1976	430	1,481	646	2,557

Table 13.—Estimated production of Pennsylvania anthracite in 1976, by week[1]

Week ended—		Thousand short tons	Week ended—		Thousand short tons	Week ended—		Thousand short tons
Jan.	1	35	May	7	130	Sept.	4	135
	8	120		14	135		11	100
	15	125		21	145		18	120
	22	130		28	145		25	125
	29	115	June	4	155	Oct.	2	125
Feb.	7	110		11	145		9	115
	14	105		18	140		16	110
	21	115		25	135		23	115
	28	110	July	2	60		30	120
Mar.	5	105		9	130	Nov.	6	123
	12	110		16	130		13	120
	19	105		23	125		20	100
	26	125		30	155		27	100
Apr.	2	110	Aug.	6	135	Dec.	4	125
	9	140		13	130		11	105
	16	105		20	125		18	125
	23	140		27	140		25	95
	30	105				Jan.[2]	1	75
						Total		6,228

[1]Estimated from weekly carloadings as reported by the Association of American Railroads and other factors; adjusted to annual production from Bureau of Mines canvass.

[2]Figures represent production in that part of week included in calendar year 1976.

Table 14.—Estimated monthly production of Pennsylvania anthracite[1]

(Thousand short tons)

Month	1972	1973	1974	1975	1976
January	583	522	516	540	525
February	542	568	458	535	440
March	622	641	531	544	525
April	487	581	563	270	520
May	706	641	589	535	555
June	515	609	505	544	610
July	465	434	443	455	490
August	688	587	620	535	590
September	611	532	516	500	515
October	682	614	641	560	490
November	650	582	610	555	493
December	555	519	625	630	475
Total	7,106	6,830	6,617	6,203	6,228

[1]Production is estimated from weekly carloadings, as reported by the Association of American Railroads, and includes mine fuel, coal sold locally, and dredge coal.

Table 15.—Pennsylvania anthracite loaded mechanically underground

(Thousand short tons)

Year	Scraper loaders		Mobile loaders		Conveyor and pit-car loaders		Total loaded mechanically[1]	
	Number of units	Quantity loaded	Number of units	Quantity loaded	Number of units	Quantity loaded	Number of units	Quantity loaded
1972	81	347	16	136	46	111	143	594
1973	72	220	4	106	47	96	123	421
1974	64	89	6	169	41	49	111	307
1975	15	66	4	188	25	44	44	299
1976	17	62	4	152	25	71	46	285

[1]Data may not add to totals shown because of independent rounding.

Table 16.—Trends in mechanical loading, hand loading, and stripping of fresh-mined Pennsylvania anthracite

(Thousand short tons)

Year	Underground					Strip pits		
	Mechanical loading	Percent of total underground	Hand loading	Percent of total underground	Total	Quantity	Percent of fresh mined coal	Total
1972	594	62.9	350	37.1	944	3,483	78.7	4,427
1973	421	58.0	305	42.0	726	3,279	81.9	4,005
1974	307	46.8	350	53.2	657	2,869	81.4	3,526
1975	299	46.6	342	53.4	641	2,564	80.0	3,205
1976	285	48.8	299	51.2	584	2,999	83.7	3,583

Table 17.—Average sales realization of Pennsylvania anthracite (excluding dredge coal) at preparation plants, by region and size

(Per short ton)

Size	1972	1973	1974	1975	1976	1972	1973	1974	1975	1976
	Lehigh region					Schuylkill region				
Egg	$18.32	$19.77	$33.23	$45.70	$50.45	$16.58	$17.32	$33.85	$53.56	$47.87
Stove	17.67	19.37	30.96	46.37	51.14	17.56	19.35	32.23	46.29	48.11
Chestnut	17.39	19.11	30.04	44.92	48.17	17.23	18.96	32.38	45.60	46.86
Pea	15.60	16.36	27.02	41.28	42.22	15.33	16.86	28.40	43.07	42.49
Total pea and larger	17.08	18.64	30.05	44.90	48.17	16.87	18.52	31.20	45.27	46.23
Buckwheat No. 1	15.29	16.87	29.35	43.55	46.15	14.85	16.00	27.77	44.13	41.49
Buckwheat No. 2 (rice)	15.06	16.89	26.56	39.67	43.71	14.95	16.34	26.74	40.08	40.38
Buckwheat No. 3 (barley)	13.82	14.99	23.80	38.31	41.90	12.36	13.82	23.11	38.94	40.86
Buckwheat No. 4	8.82	10.68	19.20	36.23	40.79	9.15	10.87	20.53	34.56	34.58
Buckwheat No. 5	6.28	8.49	20.51	31.59	31.77	5.71	8.34	18.33	23.54	26.21
Other[1]	4.81	5.13	6.25	12.27	14.02	4.70	5.83	8.41	11.92	13.57
Total buckwheat No. 1 and smaller	10.09	11.55	23.78	29.66	37.04	9.43	10.66	17.76	27.78	27.14
Total all sizes	12.35	14.09	26.45	35.10	41.45	11.48	12.67	20.81	32.19	31.83
	Wyoming region[2]					Total				
Egg	18.46	19.88	30.46	45.79	45.12	18.11	19.55	32.91	45.82	49.08
Stove	18.13	20.08	29.95	47.28	45.18	17.73	19.51	31.54	46.59	49.21
Chestnut	18.63	20.36	28.40	45.28	44.05	17.66	19.30	31.06	45.34	47.13
Pea	16.38	17.82	25.56	41.04	39.19	15.72	16.98	27.61	42.33	42.02
Total pea and larger	17.81	19.42	28.10	44.17	42.77	17.18	18.76	30.41	45.04	46.71
Buckwheat No. 1	16.23	17.46	28.02	41.36	38.39	15.38	16.60	28.36	43.50	43.03
Buckwheat No. 2 (rice)	15.60	17.93	27.57	39.46	37.98	15.12	16.77	26.73	39.86	41.20
Buckwheat No. 3 (barley)	13.87	13.91	21.92	31.10	31.85	12.97	14.11	23.16	37.43	39.53
Buckwheat No. 4	9.39	10.40	14.48	27.53	33.81	9.11	10.78	19.35	33.80	35.68
Buckwheat No. 5	7.22	8.96	14.01	27.51	31.84	5.93	8.39	18.82	25.74	28.30
Other[1]	6.60	7.15	10.66	13.07	16.29	5.16	5.78	8.77	12.29	14.24
Total buckwheat No. 1 and smaller	12.71	13.85	16.51	24.01	25.57	10.14	11.30	18.88	27.61	29.11
Total all sizes	14.94	16.33	20.11	26.96	28.19	12.40	13.65	22.19	32.26	33.92

[1]Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[2]Includes Sullivan County.

Table 18.—Average value of Pennsylvania anthracite from all sources, by region[1]

(Per net ton)

Region	1975				1976			
	Shipped by rail	Shipped by truck	Colliery fuel	Total	Shipped by rail	Shipped by truck	Colliery fuel	Total
Lehigh	$41.52	$30.02	$38.91	$35.11	$44.74	$37.90	$44.95	$41.46
Schuylkill	40.54	27.68	36.86	31.72	41.39	27.71	39.66	31.32
Wyoming[2]	38.25	25.45	46.89	26.97	33.87	27.02	35.87	28.20
Total	40.80	27.81	37.97	31.99	42.27	29.51	41.71	33.59

[1]Value given for shipments is that at which coal left possession of producing company; does not include selling expenses.
[2]Includes Sullivan County.

Table 19.—Wholesale prices of Pennsylvania anthracite in 1976, by size[1]

(Per short ton)

Size	Winter	Spring	Summer-Fall	Yearend
Egg and stove	$47.25-$47.50	$47.25-$47.50	$47.25-$47.50	$47.25-$47.50
Chestnut	47.00-47.50	47.00-47.50	47.00-47.50	47.00-47.50
Pea	42.00-42.50	42.00-42.50	42.00-42.50	42.00-42.50
Buckwheat No. 1	42.00-42.50	42.00-42.50	42.00-42.50	42.00-42.50
Buckwheat No. 2 (rice)	42.00-42.50	42.00-42.50	42.00-42.50	42.00-42.50
Buckwheat No. 3 (barley)	42.00-42.50	42.00-42.50	42.00-42.50	42.00-42.50

[1]As quoted in the Black Diamond Magazine. All prices are per short ton f.o.b. at mines.

Table 20.—Employment at operations producing Pennsylvania anthracite (including strip contractors) in 1976

	Lehigh region	Schuylkill region	Wyoming region[1]	Total 1976	Total 1975
Average number of men working daily:					
Underground	NA	NA	NA	742	733
Strip	NA	NA	NA	1,375	1,468
Culm banks	NA	NA	NA	328	400
Preparation plants	NA	NA	NA	1,226	1,291
Other surface	NA	NA	NA	(2)	(2)
Total excluding dredge operations	NA	NA	NA	3,671	3,892
Dredge operations	NA	NA	NA	15	15
Total	NA	NA	NA	3,686	3,907
Average number of days active:					
All operations except dredges	NA	NA	NA	235	213
Dredge operations	NA	NA	NA	250	275
Average, all operations	NA	NA	NA	235	214
Man-days of labor:					
All operations except dredges	NA	NA	NA	863,000	829,000
Dredge operations	NA	NA	NA	4,000	4,000
Total, all operations	NA	NA	NA	867,000	833,000
Average tons per man-day:					
All operations except dredges	NA	NA	NA	7.12	7.39
Dredge operations	NA	NA	NA	23.45	18.46
Average, all operations	NA	NA	NA	7.19	7.45

NA Not available.
[1]Includes Sullivan County.
[2]Included in operations above.

Table 21.—Distribution of Pennsylvania anthracite, calendar year 1976, by State, Province, and country of destination

(Short tons)

Destination	Pea and larger					Buckwheat No. 1 and smaller					Total, all sizes
	Broken and egg	Stove	Chestnut	Pea	Total	Buck-wheat No. 1	Buck-wheat No. 2 (Rice)	Buck-wheat No. 3 (Barley)	Other	Total	
United States:											
New England States:											
Connecticut	27	964	2,575	112	3,678	1,067	127	--	--	1,194	4,872
Maine	--	1,040	1,611	--	2,651	--	1,151	--	48	1,199	3,850
Massachusetts	77	4,711	6,398	643	11,829	285	1,707	4	1,211	3,207	15,036
New Hampshire	--	550	856	--	1,406	66	194	--	--	260	1,666
Rhode Island	--	325	565	--	890	--	--	--	--	--	890
Vermont	--	1,665	1,459	251	3,375	404	1,695	--	--	2,099	5,474
Total	104	9,255	13,464	1,006	23,829	1,822	4,874	4	1,259	7,959	31,788
Middle Atlantic States:											
New Jersey	563	8,197	22,399	3,218	34,377	1,756	2,060	2,502	85,449	91,767	126,144
New York	928	93,921	46,889	115,719	257,457	70,455	27,365	34,581	141,077	273,478	530,935
Pennsylvania[1]	4,960	81,110	247,382	195,505	528,957	278,251	432,494	392,118	1,991,606	3,094,469	3,623,426
Total	6,451	183,228	316,670	314,442	820,791	350,462	461,919	429,201	2,218,132	3,459,714	4,280,505
South Atlantic States:[2]											
Delaware	267	1,960	2,352	571	5,150	--	--	5,891	5	5,896	11,046
District of Columbia	--	2,187	1,351	105	3,643	746	116	--	12	874	4,517
Maryland	--	3,793	3,634	1,595	9,022	335	231	49	247	862	9,884
Virginia	--	501	211	84	796	147	645	1	2,749	3,542	4,338
West Virginia	--	--	77	3,224	3,301	5	3	3	11,819	11,830	15,131
Total	267	8,441	7,625	5,579	21,912	1,233	995	5,944	14,832	23,004	44,916

See footnotes at end of table.

Table 21.—Distribution of Pennsylvania anthracite, calendar year 1976, by State, Province, and country of destination —Continued

(Short tons)

Destination	Pea and larger					Buckwheat No. 1 and smaller					Total, all sizes
	Broken and egg	Stove	Chestnut	Pea	Total	Buckwheat No. 1	Buckwheat No. 2 (Rice)	Buckwheat No. 3 (Barley)	Other	Total	
United States: —Continued											
Lake States:											
Illinois	12,582	--	224	5,339	18,145	34,733	11,979	1,227	5,143	53,082	71,227
Indiana	95	--	950	28	1,073	18	65	499	11,975	12,557	13,630
Michigan	--	46,212	6,419	8	52,639	18	119	17	4,022	4,176	56,815
Minnesota	--	--	3	2	5	3	3	252	5,474	5,732	5,737
Ohio	10,588	--	56	--	10,644	6,517	2,226	1,541	37,785	48,069	58,713
Wisconsin	135	1,334	858	55	2,382	26	140	154	360	680	3,062
Total	23,400	47,546	8,510	5,432	84,888	41,315	14,532	3,690	64,759	124,296	209,184
Other States	72	318	134	9,747	10,271	132,817	1,922	14,311	208,795	357,845	368,116
Total United States	30,294	248,788	346,403	336,206	961,691	527,649	484,242	453,150	2,507,777	3,972,818	4,934,509
Canada:											
Ontario	138	30,771	21,333	1,944	54,186	11,670	4,476	3,122	16,710	35,978	90,164
Quebec	--	4,244	4,210	1,065	9,519	20,968	43,983	144,007	136,389	345,347	354,866
Other Provinces	--	--	103	13	116	18	82	24	127	251	367
Total Canada	138	35,015	25,646	3,022	63,821	32,656	48,541	147,153	153,226	381,576	445,397
Other countries	43,597	332,884	171,909	41,525	589,915	17,631	123	880	134,288	152,922	742,837
Grand total	74,029	616,687	543,958	380,753	1,615,427	577,936	532,906	601,183	2,795,291	4,507,316	6,122,743

[1]Includes "local sales."
[2]Shipments to other States in the South Atlantic area are included in "Other States."

Table 22.—Truck shipments of Pennsylvania anthracite in 1976, by month and State of destination[1]

(Thousand short tons)

Destination	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Percent of total trucked
Pennsylvania:														
Within region	117	102	93	79	72	73	71	102	95	105	121	141	1,171	32.3
Outside region	170	155	190	163	162	178	154	176	176	182	178	169	2,053	56.6
New York	26	26	19	25	29	34	24	19	24	26	26	30	308	8.5
New Jersey	4	4	5	4	4	5	2	3	2	4	6	6	49	1.4
Delaware	1	1	(2)	1	1	1	1	1	1	1	1	1	11	.3
Maryland	1	1	(2)	(2)	(2)	1	1	1	1	1	1	1	9	.2
Other States	3	2	2	1	2	2	1	3	3	3	2	2	26	.7
Total:[3]														
1976	322	291	309	272	270	294	255	304	302	321	336	350	3,626	100.0
1975	314	358	284	193	r248	293	259	306	r281	318	r222	524	r3,600	100.0

rRevised.
[1]Compiled from reports of Pennsylvania Department of Environmental Resources.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Table 23.—Shipments of Pennsylvania anthracite, by destination[1]

(Thousand short tons)

Destination	1972	1973	1974	1975	1976
TRUCK SHIPMENTS					
Pennsylvania:					
Within region	1,584	1,511	1,410	1,288	1,171
Outside region	1,793	1,758	1,943	1,923	2,053
New York	441	380	416	300	308
New Jersey	89	77	77	56	49
Delaware	15	11	11	9	11
Maryland	23	26	30	9	9
District of Columbia	(2)	--	--	--	--
Other States	21	8	30	16	26
Total[3]	3,966	3,771	3,917	3,601	3,626
RAIL SHIPMENTS					
New England States	49	45	37	29	23
New York	281	299	187	106	135
New Jersey	85	55	34	55	79
Pennsylvania	830	856	679	586	524
Delaware	2	(2)	(2)	(2)	(2)
Maryland	2	1	23	1	1
District of Columbia	3	2	3	--	--
Virginia	3	8	15	3	4
Ohio	124	122	77	50	59
Indiana	42	43	34	25	4
Illinois	47	56	61	45	66
Wisconsin	10	8	6	3	3
Missouri	30	26	30	25	19
Minnesota	10	11	28	13	6
Iowa	31	36	47	42	34
Michigan	49	98	72	63	45
Other States	290	311	316	234	244
Total United States[3]	1,891	1,977	1,649	1,280	1,245
Canada	386	389	348	303	278
Other countries	374	384	327	394	406
Grand total[3]	[4]2,651	2,750	2,324	1,977	1,929

[1]Compiled from reports of Pennsylvania Department of Environmental Resources; does not include dredge coal.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.
[4]Corrected figure; erroneously reported in 1972.

Table 24.—Consumption of Pennsylvania anthracite in the United States, by consumer category

(Thousand short tons)

Year	Residential and commercial heating[e]	Colliery fuel	Electric utilities[1]	Cement plants	Iron and steel industry: Coke making	Iron and steel industry: Sintering and pelletizing[2]	Other uses[e]
1972	2,960	11	1,584	W	474	283	603
1973	2,917	11	1,442	W	467	231	603
1974	2,577	12	1,498	W	444	367	550
1975	2,128	10	1,482	W	326	[3]237	925
1976	2,016	12	1,350	W	380	140	1,142

[e]Estimate. W Withheld to avoid disclosing individual company confidential data; included in "Other uses."
[1]Federal Power Commission.
[2]Annual Statistical Report, American Iron and Steel Institute.
[3]Annual Statistical Report, Federal Bureau of Mines.

Table 25.—U.S. exports of anthracite, by country and customs district

	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
COUNTRY				
Argentina	31	$4	140	$29
Australia	1,868	285	3,983	462
Brazil	1,071	171	489	78
Canada	543,552	20,905	445,397	16,154
Chile	373	33	1,049	124
China, People's Republic of	674	11	--	--
Colombia	57	10	--	--
Dominican Republic	10	1	--	--
Ecuador	568	97	112	2
France	39,303	1,425	105,003	3,784
Germany, West	--	--	6,657	171
India	2,215	147	--	--
Italy	11,357	391	7	1
Korea, Republic of	142	7	13	3
Liberia	--	--	946	15
Mexico	12,128	722	16,040	929
Netherlands	16,362	717	16,440	660
Panama	31	3	--	--
Philippines	225	16	1,159	102
Saudi Arabia	--	--	161	35
Surinam	344	59	617	70
Sweden	2,959	261	51	7
Trinidad and Tobago	212	18	--	--
Venezuela	5,758	499	16,552	1,335
Other	361	19	351	47
Total	639,601	25,801	615,167	24,008
CUSTOMS DISTRICT				
Baltimore	433	65	354	52
Buffalo	127,829	4,065	136,727	3,755
Chicago	--	--	580	85
Detroit	22,577	967	24,327	759
El Paso	338	11	61	2
Galveston	674	11	--	--
Great Falls	359	38	35	3
Houston	--	--	84	10
Laredo	11,540	709	15,979	927
Los Angeles	--	--	13	1
Miami	92	2	8	2
Mobile	272	48	617	70
New Orleans	2,957	501	11,658	1,021
New York City	1,011	58	3,158	175
Nogales	250	3	--	--
Norfolk	--	--	161	35
Ogdensburg	72,739	2,117	34,367	924
Pembina	30	2	2,217	38
Philadelphia	397,497	17,143	383,351	16,039
Portland, Maine	390	15	42	6
San Francisco	296	21	1,142	99
San Juan	212	18	--	--
St. Albans	75	5	--	--
Seattle	30	2	286	5
Total	639,601	25,801	615,167	24,008

Table 26.—Anthracite: World production,[1] by country

(Thousand short tons)

Country[2]	1974	1975	1976[p]
Belgium	2,247	1,661	1,133
Bulgaria	129	130	[e]120
China, People's Republic of[e]	22,000	22,000	22,000
France	6,586	5,907	[e]5,800
Germany, West	8,139	8,434	7,306
Ireland	75	53	54
Japan	154	101	42
Korea, North[e]	[r]34,000	35,000	36,000
Korea, Republic of	16,825	19,393	18,108
Morocco	633	719	774
Netherlands	883	--	--
Peru	[r] [e]11	11	12
Portugal	254	243	213
Romania[e]	22	22	22
South Africa, Republic of	1,582	1,754	2,711
Spain	3,250	3,477	3,846
U.S.S.R	83,586	84,000	84,000
United Kingdom	2,793	[e]2,793	[e]2,900
United States (Pennsylvania)	6,617	6,203	6,228
Vietnam[e]	[r]3,900	4,400	5,500
Total	[r]193,686	196,301	196,769

[e]Estimate. [p]Preliminary. [r]Revised.

[1]An unspecified amount of semianthracite is included in figures for some countries.

[2]In addition to the countries listed, Canada, Colombia, and New Zealand, produce anthracite, but the level of production is not recorded and available information is inadequate to make reliable estimates; in Colombia output may total 100,000 tons annually, while in New Zealand output is insignificant.

Table 27.—Production trends for Pennsylvania anthracite, 1890-1976

Year	Total production (short tons)[1]	Method of production (short tons)				Average productivity, tons per man-day		Quantity loaded mechanically underground (short tons)	Percentage of total loaded underground
		Deep mine	Strip mine	Culm bank	River dredging	Total	Strip		
1890	46,468,641	NA	NA	NA	NA	1.85	NA	NA	NA
1891	50,665,431	NA	NA	NA	NA	1.98	NA	NA	NA
1892	52,472,504	NA	NA	NA	NA	2.06	NA	NA	NA
1893	53,967,543	NA	NA	NA	NA	2.06	NA	NA	NA
1894	51,921,121	NA	NA	NA	NA	2.08	NA	NA	NA
1895	57,999,337	NA	NA	NA	NA	2.07	NA	NA	NA
1896	54,346,081	NA	NA	NA	NA	2.10	NA	NA	NA
1897	52,611,681	NA	NA	NA	NA	2.34	NA	NA	NA
1898	53,382,645	NA	NA	NA	NA	2.41	NA	NA	NA
1899	60,418,005	NA	NA	NA	NA	2.50	NA	NA	NA
1900	57,367,915	NA	NA	NA	NA	2.40	NA	NA	NA
1901	67,471,667	NA	NA	NA	NA	2.37	NA	NA	NA
1902	41,373,595	NA	NA	NA	NA	2.40	NA	NA	NA
1903	74,607,068	NA	NA	NA	NA	2.41	NA	NA	NA
1904	73,156,709	NA	NA	NA	NA	2.35	NA	NA	NA
1905	77,659,850	NA	NA	NA	NA	2.18	NA	NA	NA
1906	71,282,411	NA	NA	NA	NA	2.25	NA	NA	NA
1907	85,604,312	NA	NA	NA	NA	2.33	NA	NA	NA
1908	83,268,754	NA	NA	NA	NA	2.39	NA	NA	NA
1909	81,070,359	NA	NA	NA	107,788	2.31	NA	NA	NA
1910	84,485,236	NA	NA	NA	102,853	2.17	NA	NA	NA
1911	90,464,067	NA	NA	NA	106,005	2.13	NA	NA	NA
1912	84,361,598	NA	NA	NA	96,009	2.10	NA	NA	NA
1913	91,524,922	NA	NA	NA	150,064	2.02	NA	NA	NA
1914	90,821,507	NA	NA	NA	115,257	2.06	NA	NA	NA
1915	88,995,061	NA	1,121,603	NA	138,421	2.19	NA	NA	NA
1916	87,578,493	NA	1,987,800	NA	160,507	2.16	NA	NA	NA
1917	99,611,811	NA	2,301,588	NA	170,672	2.27	NA	NA	NA
1918	98,826,084	NA	2,360,183	NA	282,930	2.29	NA	NA	NA
1919	88,092,201	NA	2,006,879	NA	693,093	2.14	NA	NA	NA
1920	89,598,249	NA	2,054,441	NA	740,453	2.28	NA	NA	NA
1921	90,473,451	NA	2,027,790	NA	623,329	2.09	NA	NA	NA
1922	54,683,022	NA	949,745	NA	904,108	2.31	NA	NA	NA
1923	93,339,009	NA	2,263,098	NA	956,368	2.21	NA	NA	NA
1924	87,926,862	NA	1,865,677	NA	825,394	2.00	NA	NA	NA
1925	61,817,149	NA	1,578,478	NA	1,015,708	2.12	NA	NA	NA
1926	84,437,452	NA	2,401,356	NA	914,764	2.09	NA	NA	NA
1927	80,095,564	73,657,818	2,153,156	NA	971,817	2.15	NA	2,223,281	3.0
1928	75,348,069	69,724,862	2,422,924	NA	943,401	2.17	NA	2,351,074	3.4
1929	73,828,195	69,963,848	1,911,766	NA	716,944	2.16	NA	3,470,158	5.0
1930	69,384,837	64,926,094	2,536,288	NA	643,291	2.21	NA	4,467,750	6.9

1931	59,645,652	53,459,502	3,813,237	NA	458,750	2.37	NA	4,384,780	8.2
1932	49,855,221	43,834,160	3,980,973	NA	480,050	2.54	NA	5,433,340	12.4
1933	49,541,344	41,032,111	4,932,069	NA	538,924	2.60	NA	6,557,267	16.0
1934	57,168,291	48,574,741	5,798,138	NA	652,180	2.53	NA	9,284,486	19.1
1935	52,158,783	43,782,876	5,187,072	2,702,468	590,467	2.68	NA	9,279,057	21.2
1936	54,579,535	44,726,506	6,203,267	3,193,972	546,684	2.79	NA	10,827,946	24.2
1937	51,856,433	42,566,351	5,696,018	2,722,599	760,474	2.77	NA	10,683,837	25.1
1938	46,099,027	38,142,297	5,095,341	2,340,444	571,024	2.79	NA	10,151,669	26.6
1939	51,487,377	42,571,548	5,486,479	2,583,814	703,860	3.02	NA	11,773,833	27.7
1940	51,484,640	41,516,837	6,352,700	2,783,038	942,944	3.02	NA	12,326,000	29.7
1941	56,368,267	43,877,264	7,316,574	3,656,866	1,517,563	3.04	NA	13,441,987	30.6
1942	60,327,729	45,236,699	9,070,933	4,735,064	1,285,033	2.95	NA	14,741,459	32.6
1943	60,643,620	42,735,798	8,989,387	7,583,698	1,334,737	2.78	NA	14,745,793	34.5
1944	63,701,363	41,775,416	10,953,030	9,600,180	1,372,737	2.79	NA	14,975,146	35.8
1945	54,933,909	34,885,699	10,056,325	8,786,659	1,205,226	2.79	NA	13,927,955	39.9
1946	60,506,873	38,084,457	12,858,903	8,431,092	1,132,394	2.84	NA	15,619,162	41.0
1947	57,190,009	36,963,112	12,603,545	6,403,646	1,219,706	2.78	NA	16,054,011	43.4
1948	57,139,948	37,175,291	13,352,874	5,623,779	988,004	2.81	NA	15,742,368	42.3
1949	42,701,724	27,030,650	10,376,808	4,429,144	865,122	2.87	NA	11,858,088	43.9
1950	44,076,703	28,155,895	11,833,934	3,467,310	619,564	2.83	NA	12,335,650	43.8
1951	42,669,997	26,342,239	11,135,990	4,630,200	561,568	2.97	NA	10,847,787	41.2
1952	40,582,558	24,748,283	10,696,705	4,765,516	372,054	3.06	NA	10,034,464	40.5
1953	30,949,152	17,893,489	8,606,482	4,011,000	438,181	3.28	NA	6,888,769	38.2
1954	29,083,477	16,852,408	7,939,680	3,565,482	725,907	4.02	NA	6,978,035	41.4
1955	26,204,554	14,498,758	7,703,907	3,213,046	788,843	3.96	NA	6,660,939	45.9
1956	28,900,220	15,054,904	8,354,230	4,774,799	716,287	4.25	NA	7,308,110	48.5
1957	25,338,321	12,616,053	7,543,157	4,521,410	657,701	4.18	NA	6,657,479	52.8
1958	21,171,142	10,698,835	6,877,761	2,902,753	691,793	4.36	7.94	5,332,043	49.8
1959	20,649,286	9,415,470	7,096,343	3,420,854	716,619	5.12	9.40	4,700,542	49.9
1960	18,817,441	7,695,978	7,112,288	3,297,012	712,163	5.60	10.51	4,044,392	52.6

See footnotes at end of table.

Table 27.—Production trends for Pennsylvania anthracite, 1890-1976 —Continued

Year	Total production (short tons)[1]	Method of production (short tons)				Average productivity, tons per man-day		Quantity loaded mechanically underground (short tons)	Percentage of total loaded underground
		Deep mine	Strip mine	Culm bank	River dredging	Total	Strip		
1961	17,446,439	6,784,586	7,246,646	2,669,359	745,848	5.63	10.96	3,337,778	49.8
1962	16,893,646	6,672,922	6,822,207	2,671,466	727,051	5.92	11.01	3,065,364	45.9
1963	18,267,384	6,714,746	7,467,842	3,393,066	691,730	6.27	11.02	3,665,962	54.6
1964	17,184,251	5,888,826	7,177,188	3,412,989	705,248	6.11	10.76	3,455,034	58.7
1965	14,865,955	5,296,989	5,938,982	2,929,527	700,457	6.55	11.65	3,246,034	61.3
1966	12,941,264	4,088,144	5,253,408	2,938,095	661,617	6.87	NA	2,590,547	63.4
1967	12,256,063	3,258,000	4,740,187	3,627,000	631,660	7.21	NA	1,997,806	61.3
1968	11,460,833	2,450,000	4,696,163	3,709,000	605,920	7.62	NA	1,475,000	60.2
1969	10,472,916	2,106,000	4,578,732	3,253,000	535,369	7.45	10.06	1,326,598	63.0
1970	9,729,398	1,742,000	4,541,452	3,036,000	409,354	7.10	8.98	1,150,596	66.1
1971	8,727,325	1,286,666	4,478,350	2,572,700	389,609	6.30	8.34	669,961	52.1
1972	7,106,295	944,315	3,483,076	2,202,112	476,792	6.88	NA	593,997	62.9
1973	6,829,961	725,789	3,278,977	2,384,119	441,076	7.15	NA	421,202	58.0
1974	6,616,866	657,236	2,868,783	2,940,379	150,468	7.87	NA	307,475	46.8
1975	6,203,310	641,236	2,563,701	2,922,231	76,142	7.45	NA	298,944	46.6
1976	6,228,233	583,760	2,999,584	2,556,947	87,942	7.19	NA	284,538	48.7

NA Not available.
[1]Data may not add to totals shown because of independent rounding.

Sources: Minerals Yearbook (Fuels), Bureau of Mines, U.S. Department of the Interior; and Selected Annual Reports, Pennsylvania Department of Environmental Resources, Office of Mines and Land Protection.

Cobalt

By Scott F. Sibley[1]

Cobalt demand rebounded in 1976 from the relatively low levels in 1975. The increase followed the general resurgence in industrial activity and the favorable economic situation during the year. Demand for magnetic materials was especially high, while that for superalloys was relatively low. Total reported consumption of cobalt in the United States was 16.5 million pounds, a 29% increase over that of 1975.

A supply bottleneck occurred early in the year after bridges along the Benguela Railway, linking the cobalt-producing regions of Zaire and Zambia with the port of Lobito, Angola, were damaged by rival factions in the Angolan civil disturbances. Informal rationing by suppliers followed. Even though the rail line reportedly was repaired in August, permission for Zaire to use it was delayed. However, a favorable route via the port of East London, the Republic of South Africa, was utilized.

Government deliveries of cobalt sold from strategic stockpile excesses (6.7 million pounds) were a significant source of supply during 1976.

The major dealer for cobalt in the United States, African Metals Corp., notified customers April 6 that it would limit cobalt shipments to each buyer on the basis of average monthly deliveries over the previous 15 months plus 25%. On December 1, African Metals lifted its allocation system because of the return of its stocks to normal levels.

Legislation and Government Programs.—The General Services Administration (GSA) continued to offer for sale during most of 1976 specification-grade cobalt metal in various forms from excesses in the national stockpile. Government sales of cobalt by competitive bidding in 1976 totaled 5,130,696 pounds, compared with 4,896,384 pounds in 1975. Sales were on an unrestricted bid basis except that total sales of specification-grade material were limited to about 1 million pounds per month and 500,000 pounds per bidder per month. On April 6, GSA announced a revision of the cobalt invitation for bid MET-201. The revision provided for (1) a reduction in the total quantity of cobalt available for sale each month during April through September, (2) restriction of sales to domestic use only, and (3) a limitation on the quantity available to any one purchaser to 20% of the quantity offered each month, down from the previous limit of 50%.

On September 7, GSA announced the withdrawal of its Invitation for Bids for Cobalt PMDS-MET-201, following establishment of the Government's new

[1]Physical scientist, Division of Ferrous Metals.

Table 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt)

	1972	1973	1974	1975	1976
United States:					
Consumption	14,130	18,741	18,861	12,787	16,482
Imports for consumption	13,915	19,238	16,122	6,608	16,487
Stocks, Dec. 31: Consumer	1,193	2,451	2,047	r1,801	3,180
Price: Metal, per pound	$2.45	$2.45-$3.10	$3.10-$3.75	$3.75-$4.00	$4.00-$5.40
World producton, mine	54,752	64,856	r68,090	64,924	57,362

rRevised.

stockpile policy. From the first bid opening in April 1972, a total of 27,907,371 pounds of cobalt were sold under this invitation. Following this announcement, a government news conference was held October 1, 1976, concerning the U. S. stockpile of strategic and critical materials. A new stockpile goal for cobalt was listed as 85,415,000 pounds. The total inventory of cobalt in the stockpile as of December 31, 1976, excluding material sold but not delivered, was 40,950,635 pounds. Deliveries from the stockpile totaled about 6,698,000 pounds.

DOMESTIC PRODUCTION

There was no domestic mine production of cobalt in 1976. However, AMAX Inc., began significant production at its refinery in Braithwaite, La., and reached greatly improved operating capacity. According to AMAX's 1976 annual report, 363,000 pounds of cobalt were produced during the year; this was about five times that reported for 1975. By yearend, the refinery was operating at about 65% of capacity of 1 million pounds of cobalt per year. Nickel-cobalt and copper-cobalt matte was supplied to the plant from New Caledonia, the Republic of South Africa, and Botswana. Employees at the facility, members of the United Steelworkers of America, Local 8373, accepted a labor agreement at midyear, with a termination date of August 31, 1979. Reportedly, the new wage pact provides for increased wages, including a 90-cent-per-hour across-the-board raise effective September 1, 1976, as well as cost of living protection and other benefits.

Research by the Bureau of Mines to encourage and enable development of low-grade domestic laterites (see Technology section) continued, and the second stage of a feasibility study for a plant to process 5,000 tons per day was completed by contract consultants for the Bureau. Preliminary steps were also taken by the Bureau to evaluate the laterites as to their grade and extent. In addition, some development work was undertaken by AMAX Inc., to develop the Duluth gabbro sulfide deposits. However, environmental obstacles remain to be overcome, and no actual mining is expected before 1983.

CONSUMPTION AND USES

Consumption of cobalt in the United States remained strong throughout 1976, rising 29% over that reported in 1975. Of the cobalt consumed, 71% was as metal, 3% as oxide, 24% as salts and driers, and 2% as purchased scrap. Consumer stocks soared 77% above their 1975 yearend level, reflecting concern over the possibility of disruption of supply from southern Africa.

Major uses in 1976 were transportation (aircraft), 18%; electrical (magnets), 28%; machinery (principally cutting tools), 16%; paints (mainly driers), 15%; ceramics, 12%; chemicals, 9%; and other, 2%. The greatest

Table 2.—Comparison of selected end uses, 1975-76

Use	Percent of total	
	1975	1976
Steel:		
Stainless and heat resisting	0.3	0.2
Full alloy	1.4	1.4
Tool	2.3	1.4
Superalloys	17.6	17.0
Alloys (excludes alloy steels and superalloys):		
Cutting and wear-resistant materials	11.0	10.0
Welding and alloy hard-facing rods and materials	3.7	3.1
Magnetic alloys	16.0	21.1
Nonferrous alloys	5.4	4.9
Chemical and ceramic uses:		
Pigments	1.0	1.2
Catalysts	9.0	9.0
Ground coat frit	.7	.5
Glass decolorizer	.3	.2
Salts and driers	22.0	24.1

Table 3.—Cobalt materials consumed by refiners or processors in the United States

(Thousand pounds of contained cobalt)

Form[1]	1972	1973	1974	1975	1976
Alloy and concentrate[2]	120	14	245	340	1,186
Metal	3,063	4,028	4,754	3,162	5,001
Hydrate	16	60	46	41	47
Other	16	26	153	110	130

[1]Total consumption is not shown because some metal and hydrate originated from alloy and concentrate, and a total would involve duplication.
[2]For 1974-76, quantity given is cobalt content of imported matte.

Table 4.—Cobalt products[1] produced and shipped by refiners and processors in the United States

(Thousand pounds)

	1975				1976			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Metal	65	65	NA	NA	363	363	NA	NA
Hydrate	573	353	604	373	952	588	730	451
Salts[2]	7,625	1,749	7,515	1,726	10,876	2,545	10,888	2,444
Driers	9,120	793	8,851	772	12,783	1,112	12,551	1,089
Total	17,383	2,960	16,970	2,871	24,974	4,608	24,169	3,984

NA Not available.
[1]Figures on oxide withheld to avoid disclosing individual company confidential data.
[2]Various salts combined to avoid disclosing individual company confidential data.

Table 5.—Cobalt consumed in the United States in 1976, by end use

(Thousand pounds of contained cobalt)

Use	Quantity
Steel:	
Carbon	(1)
Stainless and heat resisting	41
Full alloy	236
High strength, low alloy	W
Electric	W
Tool	223
Cast irons	W
Superalloys	2,777
Alloys (excludes alloy steels and superalloys):	
Cutting and wear-resistant materials[2]	1,586
Welding and alloy hard-facing rods and materials	518
Magnetic alloys	3,525
Nonferrous alloys	812
Other alloys	654
Mill products made from metal powder	W
Chemical and ceramic uses:	
Pigments	207
Catalysts	1,446
Ground coat frit	90
Glass decolorizer	30
Other	7
Miscellaneous and unspecified	345
Total	12,497
Salts and driers: Lacquers, varnishes, paints, ink, pigments, enamels, glazes, feed, electroplating, etc	3,985
Grand total	16,482

W Withheld to avoid disclosing individual company confidential data; included in "Miscellaneous and unspecified."
[1]Less than 1/2 unit.
[2]Includes cemented and sintered carbides and cast carbide dies or parts.

Table 6.—Cobalt consumed in the United States, by form

(Thousand pounds of contained cobalt)

Form	1972	1973	1974	1975	1976
Metal	10,509	14,240	14,420	9,202	11,706
Oxide	733	668	536	372	462
Purchased scrap	197	264	270	342	329
Salts and driers	2,691	3,569	3,635	2,871	3,985
Total	14,130	18,741	18,861	12,787	16,482

increases during the year were in magnetic alloys (+73%), pigments (+60%), salts and driers (+39%), catalysts (+30%), and full alloy steel (+28%). Glass decolorizer and tool steel showed significant decreases. Of particular note was the accelerated demand for cobalt in magnetic materials, a reflection of the generally high demand for electric motors, loudspeakers, and various other types of electrical equipment. However, demand for superalloys, traditionally a strong factor in the cobalt market, continued to be relatively sluggish compared with recovery of other end uses. This was primarily caused by low orders for commercial aircraft. For this reason, magnetic materials exceeded superalloys, in terms of percentage of total demand, for the first time in several years. Leading end uses were salts and driers (24%), magnetic alloys (21%), superalloys (17%), cutting and wear-resistant materials (10%), and catalysts (9%). The large increase in pigments and driers may be attributed to increased construction activity and therefore increased demand for paints in 1976 relative to activity in this area in 1975.

PRICES

The producer price of cobalt remained at $4 per pound from January 23, 1975, to April 15, 1976, when it was raised to $4.40 per pound. On September 13, the price was increased to $4.90 per pound, and on December 24, 1977, the price was raised to $5.40 per pound. The first two price rises were reported to be the result of increased producer costs. The last price change was brought about by a realignment of the value of the U.S. dollar with respect to the Belgian franc. Government sales of cobalt on a "sealed bid" basis ranged from $3.55 to $5.63 per pound for specification-grade material. The weighted average price for the year was $4.44 per pound of cobalt. All dealer prices were quoted as f.o.b. New York or Chicago and applied to granules (shot) or broken cathodes in 551-pound (250-kilogram) drums. From January 1973 to January 1977, the price of cobalt rose at an actual annual rate of 21%. In terms of constant 1975 dollars, the price increase averaged 14% per year over the same period. These increases may be compared with average annual increases for a 20-year period (1957-77) of 4.8% and 1.1% for actual and adjusted prices, respectively.

FOREIGN TRADE

Exports of unwrought cobalt metal and alloys and of waste and scrap totaled 3,165,511 pounds, gross weight, having a value of $7,772,413, and went to 22 countries. Japan and West Germany received the greatest part, with 925,509 pounds (gross weight) valued at $1,817,425 and 731,780 pounds (gross weight) valued at $2,249,841, respectively. Exports of wrought cobalt metal and alloys of 726,750 pounds (gross weight), having a value of $4,655,041, went to 23 countries.

Total imports of cobalt (16,487,000 pounds, contained weight) were up 150% from those of 1975. The top five sources of cobalt imports to the United States in 1976 were Zaire (41%), Belgium-Luxembourg (15%), Zambia (10%), Norway (7%), and Botswana (6%). This was the first year since 1972 that Canada was not among the top five and the first year since 1968 that Finland has not been included. Material originating in southern Africa (that imported from Zaire, Zambia, Belgium-Luxembourg, and Botswana) accounted for 73% of total imports. Although imports from Botswana were relatively high, the reported figure was only an estimated cobalt content of the matte received for processing. A percentage of the material was lost in processing at the cobalt-nickel refinery of AMAX Inc., in Braithwaite, La.

Table 7.—U.S. imports for consumption of cobalt, by country

(Thousand pounds and thousand dollars)

Country	Metal[1]				Oxide				Other forms[2]				Total content[3]	
	1975		1976		1975		1976		1975		1976		1975	1976
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value	Content	Value	Content	Value[4]		
Australia	10	14	3	10	(5)	1	(5)	2	--	--	(5)	(5)	10	3
Belgium-Luxembourg	1,362	7,727	2,420	12,882	232	773	138	569	(5)	1	19	81	1,529	2,541
Botswana	--	--	--	--	--	--	--	--	92	366	1,049	4,658	92	1,049
Canada	415	1,441	738	3,142	--	--	--	--	(5)	(5)	(5)	1	415	738
Finland	1,105	4,459	844	3,810	--	--	--	--	--	--	--	--	1,105	844
France	33	156	291	869	(5)	(5)	--	--	(5)	(5)	--	--	33	291
Germany, West	86	158	660	2,733	1	5	(5)	1	(5)	4	(5)	(5)	87	660
Ireland	--	--	--	--	--	--	(5)	1	--	--	--	--	--	(5)
Japan	3	4	178	839	--	--	--	--	(5)	1	--	--	3	178
Netherlands	46	105	87	170	--	--	--	--	--	--	--	--	46	87
New Caledonia	--	--	--	--	--	--	--	--	196	780	137	608	196	137
Norway	706	2,743	1,130	4,674	--	--	--	--	--	--	--	--	706	1,130
South Africa, Republic of	--	--	--	--	--	--	--	--	52	207	--	--	52	--
Sri Lanka	--	--	--	--	--	--	--	--	(5)	1	--	--	(5)	--
Switzerland	--	--	(5)	3	--	--	--	--	--	--	--	--	--	(5)
United Kingdom	88	161	259	594	(5)	(5)	(5)	(5)	8	66	51	283	96	310
U.S.S.R	--	--	10	42	--	--	--	--	--	--	--	--	--	10
Zaire	2,238	8,643	6,781	29,038	--	--	--	--	--	--	--	--	2,238	6,781
Zambia	--	--	1,728	7,493	--	--	--	--	--	--	--	--	--	1,728
Total	6,092	25,611	15,129	66,299	233	779	138	573	348	1,426	1,256	5,631	6,608	16,487

[1]Includes unwrought metal and waste and scrap.
[2]Contained cobalt in copper-nickel and nickel matte for Botswana, New Caledonia, and the Republic of South Africa. Salts and compounds were imported from remaining countries.
[3]Estimated contained cobalt.
[4]Based on weighted average price for 1976, \$4.44 per pound contained metal.
[5]Less than 1/2 unit.

Table 8.—U.S. imports for consumption of cobalt, by class

(Thousand pounds and thousand dollars)

Class	1974	1975	1976
Metal:[1]			
Gross weight	14,791	6,092	15,129
Cobalt content[e]	14,791	6,092	15,129
Value	$49,661	$25,611	$66,299
Oxide:			
Gross weight	1,509	233	138
Cobalt content[e]	1,086	168	102
Value	$4,514	$779	$573
Salts and compounds:			
Gross weight	2	41	235
Cobalt content[e]	([2])	8	70
Value	$12	$73	$365
Other forms:[3]			
Gross weight	19,286	25,931	39,426
Cobalt content[e]	245	340	1,186
Value	$26,338	$39,397	$70,293
Total:			
Gross weight	35,588	32,297	54,928
Cobalt content[e]	16,122	6,608	16,487

[e]Estimate.
[1]Includes unwrought metal and waste and scrap.
[2]Less than 1/2 unit.
[3]Contained cobalt in copper-nickel and nickel matte.

WORLD REVIEW

Both mining and refinery operations around the world continued to expand. Except for closure of the Lynn Lake mine of Sherritt Gordon Mines, Ltd., nearly all operations continued production at maximum possible levels in response to a surging world demand which rebounded from its record low in 1975.

International.—At least three international consortia were active in ocean mining development during the year. However, there were no commitments to commercial ventures beyond exploration and/or technology development. Even so, commercial production of metals from the nodules could begin as early as 1982 or 1983, with production of 5 million pounds of cobalt per year by 1985. Several bills were sponsored by members of the U.S. Congress to provide insurance protection to mining companies against loss of their investments if an international authority should preempt their operations. The lending institutions appeared to require this kind of legal and financial protection before large sums of money would be made available to consortia for full-scale operations. However, no relevant legislation was passed in 1976.

Large-scale tests of deep seabed ocean mining systems were scheduled to be made in 1977-79. These would cost the companies $20 to $75 million per operation. Later development of processing systems and infrastructures may cost $300 to $600 million per operation.

The fifth session of the third United Nations Conference on the Law of the Sea, which ended September 17, produced no concrete results. The principal question appeared to be the nature of developing countries' participation in mining of sea floor areas beyond national jurisdiction. Another full conference was scheduled to convene May 23, 1977, in New York City, and an informal session was scheduled for February 28 to March 11, 1977. The topics that were to be considered included (1) establishment of an international agency to supervise the mining operations on the seabed, (2) limiting the rate of mining to the increase in world demand for nickel, and (3) the possibility of developing nations receiving technical aid to start their own mining ventures.

Australia.—Repairs and redesign of ore-processing units at the Greenvale nickel-cobalt metallurgical plant in Queensland, Australia, reportedly brought the operation close to design capacity by yearend. High-silica ore had caused excessive wear in a number of areas. This problem was overcome by selective mining of softer ores. In addition, the installation of mass flow cones to regulate ore feed in the hammer mills alleviated difficulties with bridging and flooding of the 2,000-short-ton capacity bin. Design capacity of the plant is 1,375 short tons per year of cobalt.

The project is a joint venture of Metals Exploration Queensland Pty Ltd., and Freeport Queensland Nickel, Inc. (American owned). The operation posted fiscal losses for the year which were blamed on inflation and increased oil costs. Output of cobalt contained in mixed sulfides was 764,000 pounds, or about 57% of capacity. At last report, these companies were negotiating for replacement of fixed interest and principal payments with a deferral plan, in order to ease the financial burden.

The Greenvale ore body is a laterite deposit with nickel and cobalt occurring in a residual weathering mantle, averaging about 26 feet in thickness. The overburden averages 20 feet. In addition, proven reserves are estimated at 50 million short tons, averaging 0.12% cobalt. Mine life is put at about 20 years. About 220 men are employed at the mine site, which is an opencut operation. Two trains make the run to the Yabulu treatment plant, 140 miles distant, each day. The plant is entirely self-sufficient in terms of electric power, using large amounts of heavy fuel oil from the Persian Gulf. The plant also uses about 5 million gallons of water per day. Throughput of this ammonia leach plant is about 3,025,000 wet short tons per year, with an annual cobalt production of about 1,100 short tons. The nearest port is Townsville, about 15 miles to the south.

A new discovery of manganese nodules on the sea floor southwest of Perth, Western Australia, was announced by the Bureau of Mineral Resources of Australia's Department of National Resources. The nodules reportedly occur at depths of 14,000 to 16,500 feet and have combined cobalt and nickel contents averaging 1.19%. The extent of the field has not yet been determined.

Botswana.—According to reports, in August, Botswana RST Ltd.'s (Botrest) copper-nickel-cobalt smelter at Selebi-Pikwe operated at 7% above the rated capacity of about 3,300 short tons of matte per month. This record production occurred after 2 years of plant production difficulties and was brought about by a new management team. The mining operation continued to face problems; inflated costs partially offset a rise in related metal prices, and Botrest was faced with outstanding claims by Triomf Fertilizer, Ltd. and AMAX Refining, Inc. because of the production delays, which allegedly resulted in nonfulfillment of contract. Bamangwato Concessions, Ltd., a subsidiary of Botrest and operator of Selebi-Pickwe, reported production of 72 million pounds of cobalt-bearing matte in 1976.

The sulfur section at Selebi-Pickwe experienced the most difficulty, and complete rehabilitation of the plant had to be undertaken. In the meantime, until repairs could be made, Triomf reportedly was forced to produce sulfuric acid for the manufacture of phosphoric acid at a greater cost than the contractural one. Despite all these problems, the operation was expected to reach full production levels in 1977. The local smelter provided matte as feedstock to AMAX Inc.'s refinery in Braithwaite, La.

Canada.—Sherritt Gordon Mines, Ltd., closed its Lynn Lake, Manitoba, mine in June after a serious shortfall in production targets. Problems were encountered in recruiting miners for the operation, which used cut-and-fill underground mining method, and in persistently low tonnage and grade. The Lynn Lake mine was the last major Canadian source of feedstock for Sherritt's Fort Saskatchewan refinery. Other sources used by Sherritt on a toll basis were Australia (Western Mining Corp. Ltd., and Freeport Queensland Nickel, Inc., in a joint venture with Metals Exploration Queensland, Pty Ltd.) and the Philippines (Marinduque Mining & Industrial Corp.). The refinery was shut for 2 weeks in May for annual maintenance work and for the purpose of diverting excess anhydrous ammonia to the agricultural market.

The largest producer of byproduct cobalt in Canada was International Nickel of Canada Ltd., (INCO), which recovered a crude oxide at its nickel refineries in Port Colborne, Ontario, and Thompson, Manitoba. Deliveries of cobalt in 1976 were reported as 2,430,000 pounds, up 134% from those of 1975. Cobalt oxides and salts were recovered at the company's nickel refinery in Clydach, Wales. Falconbridge Nickel Mines Ltd., reported deliveries of 2,079,000 pounds, up 52% from those of 1975.

Cuba.—Cuba reportedly planned to raise its output of nickel in sulfide, oxide, and sinter to an annual 102.5 million pounds by 1980 from about 80 million pounds in 1975. If current nickel-to-cobalt production ratios are maintained, this would mean a production of about 4.5 million pounds of cobalt in 1980, versus the current estimate of 3.6

million pounds. Furthermore, if planned expansions are executed, 7.2 million pounds of cobalt would be produced in 1985 and 14.4 million pounds in 1990. There was speculation that some of this material would be made available to Western markets.

Indonesia.—P.T. Pacific Nikkel Indonesia, Ltd., (PNI), made steady progress during the year in the task of assembling financing for its Soroako project on the Island of Sulawesi. The deposit has the potential for production of 100 million pounds per year of nickel and 4 million pounds per year of cobalt in the form of mixed sulfides. PNI reportedly will use a $25 million Australian loan to buy Australian goods and services for the second stage of development. The loan for the $800 million project was arranged by the Australian-supported Export Finance and Insurance Corp. Included in the project plans are an open pit mine, a reduction and smelting plant, and hydroelectric and thermal power generation facilities. Much of the infrastructure will be developed by Australian companies.

India.—Construction of the first Indian nickel-cobalt smelter, to be located at Sukinda in Orissa Province, reportedly will not begin until sometime during the sixth plan (April 1979-March 1984). The project was postponed from a 1976 target date because of a delay in commissioning a pilot plant for the processing of laterite ore in the Kansas area. The plant capacity was to be 210 short tons per year of cobalt.

Japan.—The Nikko Nickel Cobalt Smelting Co., Ltd., a subsidiary of Nippon Mining Co., Ltd., began production of cobalt at its Nitachi plant during the year. Production reached about 51 short tons per month at yearend, and the capacity level of 110 short tons per month was expected to be reached in 1977. The facility was built at a total cost of $14.3 million. Australian feed material (a mixed sulfide containing 15% cobalt and 39% nickel) was delivered to the plant.

Sumitomo Metal Mining Co., Ltd. also began commercial production of metallic cobalt and nickel at its Besshi plant, Ehime Prefecture. Feedstock for the plant was imported from Marinduque Mining & Industrial Corp. in the Philippines. Annual capacity of the plant is 1,760 short tons of cobalt. The facility was completed in September at a cost of $13.3 million and was producing cobalt at the rate of about 70 tons per month by yearend.

Both Nikko Nickel and Sumitomo employed the solvent extraction process for separating cobalt and nickel from mixed sulfides. Nikko Nickel used sulfuric acid as a solvent, while Sumitomo used hydrochloric acid. The two refineries are expected to supply 50% of Japan's refined cobalt requirements.

Philippines.—Marinduque Mining & Industrial Corp. continued to experience technical difficulties at its Nonoc Island nickel-cobalt refinery, which reportedly has an annual production capacity of approximately 3.3 million pounds of cobalt in mixed sulfides. In May, the refinery operated at about 66% of rated capacity, and there was no substantial improvement by yearend. The plant was shut down for 3 weeks in November for annual maintenance and installation of a new gas plant boiler. The main plant operating problems were (1) the reliability of services such as power, steam, and hydrogen and carbon dioxide gases, (2) training of supervisory personnel, (3) roaster availability, (4) parts supply, (5) first-stage-leach-circuit cooling capacity, and (6) excessive ammonia consumption.

Rhodesia, Southern.—Rio Tinto (Rhodesia), Ltd., reportedly was to build a cobalt plant to treat residues from its Empress nickel mines near Gatooma in the Rhodesian midlands. The plant was to be financed by an offer of new shares to existing shareholders and would cost approximately $530,000. According to an official of the company, the plant would start as soon as financing was secured and would be onstream by about January 1977.

Zaire.—A supply shortage occurred early in the year after bridges along the Benguela Railway, linking the mineral-rich regions of Zaire and Zambia with the port of Lobito, Angola, were damaged by rival factions in the Angolan civil disturbance. Informal rationing by suppliers followed. Even though the rail line was repaired in August, Angola reportedly delayed granting Zaire permission to use it. However, Zaire found a favorable route via the port of East London, the Republic of South Africa. Deliveries of cobalt to the United States from July through December continued at a relatively high level, commensurate with demand.

Although Zaire made some use of the port of Matadi on the Atlantic Ocean, the eastern and southern routes carried the greatest portion of cobalt exports. In particular, Zaire made use of the Tazara Railway from Zambia to Dar es Salaam on the Indian

Ocean (the eastern route). Reportedly, however, about one-third of Zairian copper and cobalt moved on the southern route through Rhodesia during the year. Two other less direct routes were also used. One was by rail to Lake Tanganyika, which was crossed by ferry; another rail line through Tanzania completed the route. The other, less-traveled route was by rail to the interior Zairian town of Llebo, where the material was transferred to barges or trucks and shipped to the port of Matadi on the Atlantic Ocean. Reportedly, Zaire made a formal request to Zambia to intercede on Zaire's behalf with the Tazara Railway Authority in Tanzania to obtain formal shipping rights. Meanwhile, guerrilla activity continued in Angola; rebel forces claimed to have blown up sections of the Benguela Railway seven times in the last half of 1976. Prior to 1976, this line was used to transport large quantities of copper and cobalt to the Atlantic. Several alternate routes to ports in Mozambique were blocked when Mozambique closed its border with Rhodesia.

Compounding these transportation problems was Zaire's financial crisis. This was brought about by Zaire's mounting overseas debt, which was estimated at about $1.4 billion at yearend, with interest and principal payments in arrears by about $19 million. Conditions reportedly were set by lending institutions such that if Zaire paid off the amount in arrears in approximately the first 9 months of 1977, a loan of $250 million would be extended. However, tight International Monetary Fund guidelines had to be met.

The proposed $880 million project of Société Minière de Tenke Fungurume (SMTF) remained stalled during the year because of inability to obtain financing. In part, lending institutions were reluctant to extend credit because of the civil strife in neighboring Angola and resultant transportation problems; three additional reasons were spiraling costs, the possibility of mining of cobalt- and copper-bearing manganese nodules from the seabed, and an expected depressed copper market. However, according to officials of Anglo-American Corp. of South Africa Ltd., one of several partners in the project, the proposal may be reworked to encompass a smaller scale operation. According to an official of Charter Consolidated, Ltd., another partner, the project might be reactivated if the price of copper moved into the range of 90 cents to $1 per pound. Prospects for reactivation appeared to be dim at yearend since drilling rigs and other equipment due for shipment to SMTF were sold. About 14 million pounds of cobalt per year was to have been produced. Tied in with suspension of this project are problems with the Shaba power line, which was to have supplied SMTF with its power needs. The 1,500-mile line fell 1 year behind schedule because of payment defaults to Swedish and Italian contractors and withdrawal of an American construction firm.

The plan by Générale des Carrières et des Mines (GÉCAMINES) to expand its operations through a 5-year development plan slowed during the year because of finance problems. However, some progress was made. Tenders for an industrial complex at Luilu in the Shaba region were called for by GÉCAMINES. The complex reportedly will consist of a flash smelting unit and a pyrometallurgical plant using coke and carbon as fuel and lime as a processor. The tender was for construction of the complex, a storage area, and preparation of the fuel and processing units. The construction is part of a plan to produce 40 million pounds of cobalt per year by 1980.

Two additional problems surfaced during the year. The Belgian companies, which had largely returned marketing functions to the Government of Zaire, reportedly were called back to help with technical and marketing matters. An unrelated problem was a shortage of metallurgical coke supplied by Rhodesia. The shortage reportedly was brought on by political sabotage and chronic transportation problems.

Zambia.—As with Zaire, lack of adequate transportation was a major problem during the year. At yearend, there were unconfirmed reports that Zambia was reviewing its border closure with Rhodesia and that there might be a change of policy allowing shipments to cross the border. The Tazara Railway, which runs through Tanzania, accelerated cargo loads from seven to nine per week at midyear in an effort to speed up copper and cobalt exports. Reportedly, the backlog of copper at the terminal port of Dar es Salaam was cleared up at midyear. Zambia's route to Lobito, Angola, was cut off by the Angolan civil war and had not been reopened by yearend. Although landlocked Zambia is independent of Rhodesia's transport system, Zambia's electricity originates in and is controlled by Rhodesia. Electricity is produced at the Kariba South hydroelectric plant, which is jointly controlled by the two countries.

Despite the relatively depressed copper market, Roan Consolidated Mines reportedly planned to expand its Chambishi facilities on the Copperbelt. This would substantially increase Zambia's cobalt production by 1978.

Table 9.—Cobalt: World production, by country

(Short tons)

Country	Mine output, metal content[1]			Metal[2]		
	1974	1975	1976[p]	1974	1975	1976[p]
Australia	1,188	2,986	[e]3,840	--	--	--
Botswana	36	89	165	[e]9	[e]9	[3]78
Canada[4]	1,724	1,493	1,513	359	640	879
Cuba[e]	1,800	1,800	1,800	--	--	--
Finland	[e]1,400	1,545	1,410	895	905	983
France	--	--	--	[r]848	774	938
Germany, West	--	--	--	392	375	[e]385
Japan	--	--	--	11	53	568
Morocco	[r]1,793	2,162	950	--	--	--
New Caledonia[e 5]	2,113	2,264	1,984	--	--	--
Norway[6]	NA	NA	NA	1,365	852	635
Philippines	[r e]33	117	514	--	(7)	--
U.S.S.R.[e]	1,900	1,950	1,950	1,900	1,950	1,950
United States	--	--	--	--	33	182
Zaire	19,436	[e]15,430	[e]12,125	19,362	15,033	11,779
Zambia	2,622	2,626	[e]2,430	[r]2,165	2,895	[e]2,700
Total	34,045	32,462	28,681	27,306	23,519	21,077

[e]Estimate. [p]Preliminary. [r]Revised. NA Not available.

[1]In addition to the countries listed, Bulgaria, Cyprus, East Germany, Greece, Poland, Spain, Sweden, and Uganda are known to produce nonferrous ores that contain a recoverable amount of cobalt, but available information is inadequate to permit formulation of reliable estimates of output levels. Other nations may also produce ores containing cobalt as a byproduct component.

[2]In addition to the countries listed, the United Kingdom recovers cobalt metal from intermediate metallurgical products produced in Canada, but data on this output are not reported by the United Kingdom and are inseparable from the total reported by Canadian producers; Czechoslovakia presumably recovers cobalt from material imported from Cuba, but no data are published and available general information is inadequate for formulation of reliable estimates of output levels. Belgium imports substantial quantities of crude materials containing cobalt, but output of metal has not been reported in recent years; production of cobalt metal and/or cobalt compounds, however, has continued.

[3]Sales.

[4]Actual output not reported. Data presented for mine output are total cobalt content of all products, including nickel oxide sinter shipped to the United Kingdom for further processing. Data presented for metal output represent the mine output just described less the cobalt metal output reported for Norway. Thus the metal output data include cobalt content of oxides and other compounds that are not produced as metal and the total cobalt metal output in the United Kingdom from Canadian materials, as well as actual metal output in Canada itself.

[5]Cobalt contained in matte and ferronickel produced; additional cobalt is contained in concentrates exported for further processing, but content of such ores is not reported and available general information is inadequate to permit formulation of reliable estimates of the cobalt content of this material.

[6]Data on domestic mine production, if any, are not available, but if output has continued, a small part of the recorded metal output may be from domestic raw materials, rather than from imported Canadian nickel-copper-cobalt matte.

[7]Revised to zero.

TECHNOLOGY

The Bureau of Mines was actively engaged in research aimed at reducing U.S. import dependence. At the Rolla Metallurgy Research Center, experiments were conducted on recovering cobalt and nickel from Missouri lead ores. The objective of this project is the development of procedures for concentrating, extracting, and recovering cobalt and nickel as byproducts during the concentration and smelting of these ores. The Albany Metallurgy Research Center in Oregon worked on the recovery of cobalt, nickel, and copper from domestic laterites, which occur principally in southwestern Oregon and northern California. Singmaster and Breyer, metallurgical and chemical process engineers, New York, N.Y.,[2] completed the first phase of a government contract to study the technical and economic feasibility of operating a 5,000-ton-per-day commercial-scale plant to extract the metals based on the process developed by the Bureau of Mines.[3]

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[2]Siemens, R. E., P. C. Good, and W. A. Stickney. Recovery of Nickel and Cobalt From Low-Grade Domestic Laterites. BuMines RI 8027, 1975, 14 pp.

[3]Siemens, R. E., and J. D. Corrick. Process for Recovery of Nickel, Cobalt, and Copper From Domestic Laterites. Min. Cong. J., v. 63, No. 1, January 1977, pp. 29-34.

The Bureau's Twin Cities, Minn. Metallurgy Research Center conducted research on processing of ores of the Duluth gabbro complex, which extends in a great arc from Duluth to the northeastern point of the State and contains about 0.04% cobalt. An analysis of the composite bulk copper-nickel concentrate produced thus far revealed a range of 0.1% to 0.4% cobalt.[4]

At the Reno Metallurgy Research Center in Nevada, Bureau scientists developed a cobalt rare-earth magnet with an energy product of 9.5 megaoersteds. The magnet contained 35% mischmetal plus other selected elements, which enabled replacement of up to 10 weight-percent cobalt. Based on this research, cheaper high-energy magnets may be made available. A patent on the new magnet was applied for.

A British research firm reportedly produced a cobalt-bearing powdered metal alloy with cutting properties superior to those of high-speed steel. The alloy is made by induction-melting powders containing 45% cobalt, atomizing in an inert gas, and then cold-compacting and sintering to produce preforms with 15% to 20% porosity. The preforms are then forged in a hydraulic press to nearly 100% of theoretical density. Hardness of the finished product reportedly is about Rockwell C 65.[5]

An improved cobalt-base conventional alloy, Capivac IV (Co-25Cr-10Ni-7W-4Ta-0.5Ti-0.62Al), recommended for investment castings, was developed by a major specialty alloy manufacturer. The alloy reportedly overcomes two major problems associated with other cobalt-base turbine alloys. These problems are poor low-temperature ductility and reactivity with mold materials. The latter problem was overcome by eliminating zirconium, which causes surface oxidation of cast parts. Room temperature ductility of the new alloy is two to three times that of zirconium-bearing cobalt-base alloys.[6]

A principal manufacturer of nuclear parts reportedly is using cobalt-base alloy bonnet and seat inserts in valves manufactured for nuclear power stations. The alloy has the trade designation Haynes No. 6PM, and reportedly has been found effective against borated water for both pressurized and boiling water reactors. The seats are shrink-fitted in forged steel valve bodies by chilling the seat rings in liquid nitrogen and heating the valve bodies to about 200°C. The valves are designed to last 40 years and are rated for water, oil, or gas service.[7]

In the general field of superalloys, increasing attention reportedly was being paid to refining current fabrication processes rather than developing new alloys. Working with conventional materials, significantly improved properties are becoming ever harder to achieve. Moreover, increased strength at high temperatures means greater difficulty in hot working the material. Test costs also inhibited development of new alloys, which may possess only marginally improved properties. An example of these new fabrication developments is the significant strides made by industry in directionally solidified eutectics and single crystals for use in jet engine component parts. The purpose of this research is the attainment of higher operating temperatures in jet engines, considered important because engine efficiency is increased at higher temperatures, while pollution is decreased.[8]

The techniques in which major advances were made include hot forging, precision metal working, hot isothermal pressing (HIP) to near net shapes, powder metallurgy, particle metallurgy, and cold pressing. The latter two were used extensively in tool steel fabrication. By use of HIP techniques, the need for recycling large quantities of superalloy scrap generated by machining may be eliminated. One exception to this trend away from new alloy development is the amount of research being conducted in the area of silicon carbide composites, which may eventually result in higher operating temperatures in jet engines than can be reached with alloys currently in use.[9]

The Third International Symposium on Superalloys was held September 12 to 15. Advances in turbine technology and metallurgy of superalloys were reviewed at the conference. Energy system applications for superalloys were considered to have great potential. At an international workshop on rare earth metals at the University of Dayton, cobalt-rare earth magnet applica-

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[4]Schluter, R. B., and A. B. Landstrom. Continuous Pilot Plant Testing Confirms Floatability of Duluth Complex Sulphides. Eng. and Min. J., v. 177, No. 4, April 1976, pp. 80-83.

[5]Industry Week. Emerging Technologies. V. 187, No. 7, Nov. 17, 1975, p. 26.

[6]Materials Engineering. New Superalloys, Better Processing Promise More Durable Turbine Parts. V. 84, No. 3, September 1976, pp. 22-24.

[7]Stellite Digest. PM Inserts Used in Seats and Bonnets of Nuclear Valves. V. 27, No. 5, November 1976, p. 1.

[8]American Metal Market. High Temperature Alloys (Supplement), Looking to the Future. V. 82, No. 229, Nov. 24, 1976, 30 pp.

[9]Van Cleave, D.A. New Ceramic Takes High Temperature Knocks. Iron Age, v. 219, No. 9, Mar. 7, 1977, pp. 66-67.

tions were reviewed and regarded as having high potential, particularly in electric motors and automobile accessory devices.

Perhaps the most significant cobalt research in progress during the year was the development of techniques for mining and processing cobalt-bearing manganese nodules from the ocean floor. Many patents have been issued on all phases of the new technology. Nevertheless, there was a debate as to whether hydrometallurgical or pyrometallurgical techniques would be more effective and economical in processing the nodules. The principal factors to be weighed are energy requirements and reagent costs. Pyrometallurgical processes are basically energy intensive. Moreover, the smelting of nodules requires the production of manganese, and because wet, impure 30% Mn nodules are inferior as an ore to 45% to 50% terrestrial material, the smelting method is considered by many not to be economically feasible. In the case of hydrometallurgy, three main processes were being studied. These were sulfuric acid, hydrochloric acid, and ammoniacal leach procedures. For the ammoniacal leach process, investment and reagent costs reportedly are relatively low, while energy requirements are high compared to the sulfuric acid route. However, in comparing the ammoniacal with the sulfuric acid process, high energy costs are more than offset by higher reagent costs of the sulfuric acid process. The HCl process would be more attractive with a higher manganese price. In addition, materials investment costs are high because of the need for materials with high corrosion resistance.[10]

In one patented process, developed by Deepsea Ventures, Inc., a mixture of finely divided manganese ore and at least a stoichiometric amount of a sulfide ore of copper, lead, nickel, or cobalt is contacted in an aqueous slurry with hydrogen chloride, hydrogen bromide, or hydrogen iodide, and the slurry is reacted to dissolve manganese and base metals. Elemental sulfur is also formed, while leaving substantially all of the iron impurity in the solid residue. The leach liquor is treated to crystallize solid manganese halide, the crystalline material is removed, and the low-iron, low-manganese leach liquor is processed for cobalt, nickel and copper and/or recycled.

Several prototypes for mining nodules were being tested, and a decision on commercial mining equipment to be used was expected before July 1978. In one method, a sea floor dredge head is used to gather nodules. The nodules are then cleaned and crushed under water and hydraulically hoisted to the recovery ship. By another method, a series of buckets are mounted on an extremely long loop of cable. The buckets are then dragged along the ocean bottom and hauled to the ship in a continuous operation. Several patents were issued on the lifting technology alone. For example, researchers for INCO (U.S. Patent 3,975,054, dated Aug. 17, 1976, and U.S. Patent 3,973,575, dated Aug. 10, 1976) developed an apparatus and method whereby a towed subsurface vehicle uses a motor-powered water jet to dislodge solids from the sea bottom. These are then collected in a hopper and trough, in which they are sorted and directed to a conduit for delivery to a surface ship.

In the field of laterite and sulfide processing, Freeport Minerals Co. received a patent (U.S. Patent 3,981,968) on recovery of nickel and cobalt values from an ammoniacal ore leach solution. In the process, the solution is contacted with an oxime extractant, and the nickel-enriched extractant phase is separated and stripped with sulfuric acid, first to remove the nickel (at ambient-temperatures), and then to remove cobalt at 170° to 300°F.

In what could be a significant development if cobalt prices continue to rise, Sumitomo Metal Mining Co., Ltd. developed a process (U.S. Patent 3,954,448, dated May 4, 1976) for recovering cobalt and other values from cobaltiferous copper converter slag or matte. The slag or matte is smelted to form a high-cobalt alloy, which is then heated with cupric sulfate and water. The resultant sulfate mixture is calcined to decompose iron sulfate, and the calcine is water-leached to dissolve cobalt sulfate.

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[10]Agarwal, J.C., N. Beecher, Davies, D.S., Hubred, G.L., Kakaria, V.K., and Kust, R.N. Processing of Ocean Nodules: A Technical and Economic Review, No. 4. April 1976, pp. 24-37.

Coke and Coal Chemicals

By Staff, Division of Coal

Production of all coal coke in the United States in 1976 was 2% more than in 1975, principally to satisfy an 8.8% increase in production of pig iron and ferroalloys in blast furnaces. Also contributing to the increase were a 15.1% increase in shipments of foundry coke and a 36.9% increase in coke shipped for other industrial plants.

Total coke production remained relatively constant throughout the year and averaged 4.86 million tons per month. The average daily output from all slot-type and beehive plants ranged from a low of 148,000 tons in January to a high of 166,000 tons in June. Average daily total output in 1976 was 160,000 tons.

During the year, the production of coke exceeded demand. Producers' stocks of oven coke, excluding coke breeze, at 6.49 million tons were 1.49 million tons greater at yearend 1976 than yearend 1975.

Blast furnaces continued to use the major portion of the Nation's coke production, receiving 92.5% of the 56.80 million tons of coke distributed by producers. The consumption of coke per ton of hot metal produced at blast furnaces averaged 1,188 pounds, compared with 1,222 pounds in 1975.

The coke equivalent of fuels injected through blast furnace tuyeres amounted to 102.4 pounds of coke equivalent (at 13,000 Btu per pound) per ton of hot metal, compared to 98 pounds of coke equivalent in 1975.

Breeze production in slot ovens averaged 102.4 pounds per ton of coal coked because of reportedly extended coking times and the slightly reduced use of low-volatile coals in the mixtures carbonized. Breeze is unsuitable for almost all metallurgical applications because of its small size and high-volatile and ash contents. The larger part of the breeze production was used by producers for sintering iron-bearing dust and fine ores and for other industrial purposes. However, 42.5% of the output was sold for industrial uses other than as fuel for steam plants or in agglomerating plants. The tonnage of breeze sold was 5.5% less than in 1975 and brought an average of $32.56 per ton, up from $32.21 in 1975.

The average cost of all bituminous coals and anthracite carbonized in slot ovens decreased $0.05 per short ton to $44.16 per short ton. This decrease was reflected in the average value of coal per ton of coke, which decreased $0.52 per short ton to $64.03 per ton. The largest price increases occurred in foundry coke sales. Foundry coke prices, which averaged $114.45 per ton f.o.b. plant, were $7.93 per ton higher than in 1975.

The production of tars was 1.4% less, and that of crude light oil was 1.7% greater, than in 1975. Production of coke-oven gas increased 1.9% compared to that of 1975, and 1.3% more coal was carbonized.

Foreign trade was somewhat greater, with coke exports, at 1.31 million tons, equal to 2.25% of domestic production. About 83% of the exported coke went to Canada, the Netherlands, West Germany, and Mexico. Coke imports were 27.9% less than in 1975, and exports were up 3.3%.

The total value of all coals carbonized was $3,699.1 million, and the total value of all carbonization products was $5,940.7 million. The combined value of coke and breeze, the principal products, accounted for 84.5% of the total value of all products.

Legislation and Government Programs.—The U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) published in the Federal Register of October 22, 1976, a final job standards on exposure to coke oven emissions, to become effective January 20, 1977. In addition to imposing specification and performance standards on coke oven operations, many engineering controls and work practices on oven batteries were required. The standard set 150 micrograms of benzene soluble fraction in the total particulate matter per cubic meter of air, averaged over an 8-hour period, as the maximum employee exposure. All oven batteries producing foundry coke by late 1976 had most of the required engineering controls and all followed most of the required work practices. The coke-oven emissions standards will probably not materially affect oven production, but the costs to the foundry coke producers of complying with the standards will undoubtedly contribute to the spiral of inflation.[1]

The American Iron and Steel Institute (AISI) and the Environmental Protection Agency (EPA) in late 1976 signed contracts totaling $960,000 to cosponsor a study by Battelle Memorial Institute. The study was to develop and demonstrate an improved coke oven door-sealing system. AISI and EPA also sponsored a project, completed at a cost of $1.85 million at Jones & Laughlin Steel Corp., designed to reduce emissions during the charging of coke ovens.[2] OSHA's first Inflation Impact Statement (IIS) stated that imposing coke oven emission standards for particulate emissions would add $2.50 per ton to the price of steel and a negligible 0.01% to the consumer price index. Meeting the limits would require capital expenditures of $451 million by the steel industry and add $173 million to its annual operating costs. The industry would be forced to hire 5,000 new employees.[3]

The Armco Steel Corp's Houston, Tex., coke plant met a court-imposed deadline (July 31, 1976) for the requirement of a larry car for charging the plants 62 ovens without emissions, and a collection shed and electrostatic precipitator for treating the particulate-laden gases emitted during coke discharge. A second phase of the modernization will cost $4 million, for recovering byproducts from about 6 billion cubic feet per year of flared gases or cleaning the gas for use in the plant as fuel. The annual recovery of other products will include 4.5 million gallons of coal tar, 1.4 million gallons of naphthalene-enriched light oil, and 7.5 million pounds of ammonium sulfate.[4]

Armco Steel Corp. received approval in July 1976 for the continued operation of its New Miami, Ohio, coke ovens from Federal and State environmental protection agencies. In return, the company pledged $17.6 million for pollution control measures.[5]

In late September 1976, EPA filed a civil suit against Interlake, Inc., charging the steel producer with violating air pollution standards at its 100-oven coke plant in Chicago, Ill. A company spokesman claimed that EPA refused to approve a pollution control system using untried experimental technology at Interlake's Toledo, Ohio plant.[6]

Problems in reducing coke-oven emissions will cost United States Steel Corp. more than $600 million. In a consent decree issued in October 1976, the firm agreed to close 13 of its Clairton Works coke batteries by 1984, rehabilitate 7 others, and construct 3 new superbatteries using the best available emission control-technology.[7]

The Ohio Environmental Board of Review issued an order delaying the charging of Republic Steel Corp.'s new 51-oven battery until hearings could be held on December 14. The new $35 million facility is one of six operated at the Cleveland, Ohio works, each with an 825-ton-per-day coke capacity. Republic claimed that all necessary equipment had been installed and was ready for operation, except for a $4.7 million pushing control system.[8]

In compliance with a Federal order, United States Steel, shut down three coke-oven batteries at its Gary, Ind. plant, terminating a 3-year dispute with EPA. About 200 workers were laid off at least temporarily. In a confirming statement regarding the shutdown, United States Steel stated that air quality would scarcely, if at all, be improved. The idle oven batteries had provided 2,000 tons of coke and 21.8 million cubic feet of coke oven gas per day.[9]

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[1]Ferguson, Lucian M. The New OSHA Coke Oven Standard. Foundry Facts. (ACCCI), January 1977, p. 10.
[2]Journal of the Air Pollution Control Association. V. 26, No. 12, December 1976, pp. 1174-75.
[3]Chemical Engineering News. V. 54, No. 13, Mar. 22, 1976, p. 10.
[4]Chemical Engneering V. 83, No. 18, Aug. 30, 1976. p. 55.
[5]Wall Street Journal. V. 188, No. 8, July 19, 1976, p. 4.
[6]Wall Street Journal. V. 82, No. 186, p. 4.
[7]Wall Street Journal. V. 188, No. 72, Oct. 12, 1976, p. 2.
[8]Chemical Week. V. 119, No. 16, Oct. 20, 1976, p. 18.
[9]Chemical Engineering. V. 83, No. 2, Jan. 19, 1976, p. 49.

Table 1.—Salient coke statistics

	1972	1973	1974	1975	1976
United States:					
Production:					
Oven coke ---- thousand short tons--	59,853	63,496	60,737	56,494	57,728
Beehive coke------------ do----	654	829	845	713	605
Total --------------- do----	60,507	64,325	[1]61,581	57,207	58,333
Exports ----------------- do----	1,232	1,395	1,278	1,273	1,315
Imports ----------------- do----	185	[r]1,078	3,540	1,819	1,311
Producers' stocks, Dec. 31 ------ do----	2,941	1,184	935	5,001	6,491
Consumption, apparent-------- do----	60,046	65,765	64,092	53,687	56,834
Value of coal-chemical materials used or sold-------------- thousands--	$294,905	$355,667	$652,735	$653,958	$919,834
Value of coke and breeze used or sold----------------- do----	$2,080,074	$2,575,150	$4,609,209	$4,607,292	$5,020,857
Total value of all products used or sold --------------- do----	$2,374,979	$2,930,817	$5,261,944	$5,261,250	$5,940,691
World production:					
Hard coke ------- thousand short tons--	381,315	403,254	[r]404,996	[r]400,470	404,713
Gashouse and low-temperature coke ----------------- do----	21,671	19,516	[r]20,032	[r]18,816	18,223

[r]Revised.
[1]Data do not add to total shown because of independent rounding.

COKE AND BREEZE

DOMESTIC PRODUCTION

An increase in the production of pig iron and ferroalloys in 1976 largely accounted for a 6.2% increase in the demand for blast furnace coke. Output of oven coke plus beehive coke averaged 4.86 million tons per month, with 5.09 million tons produced in March and 5.12 million tons in May. Daily production for the year averaged 160,000 tons, up 1.9% from the average daily output of 1975.

Forty-eight furnace plants produced 92.4% of the slot-oven coke produced. These plants, owned by or financially affiliated with iron and steel companies, were operated mainly to produce coke for iron blast furnaces. The remaining oven coke was produced by 13 merchant plants, who sold blast furnace, foundry, and other grades of coke on the open market.

Coke was produced in 19 States in 1976. The relative amounts of coke produced in the various States have changed little in the past decade. Because coke is used principally as a fuel and reducing agent in blast furnaces, the coke industry is concentrated in the major steel-producing areas of the Eastern and North Central States. The bulk of the 1976 output came from 14 States east of the Mississippi River. Three plants in California, Colorado, and Utah produced 5.6% of the total production. Pennsylvania, the largest producer, accounted for 28% of the output, followed by Ohio and Indiana, these three States accounted for 56.4% of the national output.

An average of 1,384 pounds of breeze-free coke was produced for each ton of coal carbonized in the United States in 1976. The 1976 yield of coke, which averaged 68.92%, has remained nearly constant during the past decade.

The term "coke-breeze" generally refers to a mixture of carbonized bony coal, slaty rock, and coke particles passing through a 1/2-inch-square screen. Approximately 31.4% of the 1976 breeze production was used as fuel in agglomerating plants. The remainder was used in steam plants and in the production of elemental phosphorus from phosphate rock. The amount of breeze sold has increased significantly in recent years; about 42.5% of the 1976 production was sold.

The breeze yield per ton of coal carbonized is influenced by oven-operating practices, the types of coals used, and the extend, of pulverization of coal mixtures carbonized. The lowest yield, 2.99%, was attained in Pennsylvania, while Illinois had the highest yield at 9.74%. The national yield, at 5.12%, has not varied significantly during the past decade.

Oven-coke plants averaged 102.4 pounds of breeze produced per ton of coal carbonized. The yields at beehive coke plants was substantially higher than those of oven plants, but beehive breeze production was negligible because only a few plants had recovery facilities.

According to a Bureau of Mines Special Publication,[10] an expanded program of coke-oven construction in the United States is necessary to avoid a coke shortage in 1985. The author estimated that the probable iron demand of 107 million tons would require 59 million to 62 million tons of coke. Without additional oven construction, the net capacity deficit would range between 5 million and 10 million tons. The report states that currently operating ovens, representing about one-fifth of the theoretical maximum slot-oven coke productive capacity, are more than 30 years old, and an additional 12% are more than 20 years old. The number of domestic coke ovens in late 1976 was 13,324.

Kaufman[11] states that the costs for replacement facilities now under construction exceed $1 billion and that an additional $1 billion for replacement conductive capacity will be needed during the next 10 years.

Rev. William T. Hogan, S. J., Director, Industrial Economics Research Institute, Fordham University, when questioned on emerging shortages of steelmaking raw materials, stated that "there is an even more important area to monitor as steel demand accelerates: Shortages of metallurgical coal and coke could appear. Coke is basic to steelmaking. Two factors at work are the need for more coal mining capacity, and the reductions in coke-making capacity brought on by EPA air pollution control regulations. Some coke-making operations have been slowed down because operating rates have been trimmed back to meet EPA requirements."[12]

According to a Fordham University steel industry specialist, the United States can make 63 to 66 million tons of coke annually. The specialist further stated that "if the U.S. steel industry is going to increase steel capacity, it will also have to increase coke capacity. If the raw steel production is to reach 135 million tons in 1977, some imported coke may be needed."[13]

In mid-May, Armco Steel Corp. filed a breach-of-contract suit against Allied Chemical Corp., seeking $217 million for alleged violations of coke and coke-oven gas agreements. Armco charged that Allied did not comply with EPA and other regulations to repair and maintain No. 3 and No. 4 coke-oven batteries at Allied's Ashland, Ky. plant, and that the firm refused to heed Armco's demands to do so. The suit also charged that Allied's Ironton, Ohio, and Ashland, Ky., plants were permitted to fall into a state of gross disrepair, causing decreased production of coke and recovery of coke-oven gas.[14]

Armco's Steel Corp's new No. 1 battery of 19-feet, Carl Firma Still ovens at Middletown, Ohio, was charged October 27, 1976. A similar new No. 2 battery was scheduled for charging in late December 1976. Both coke batteries will be top charged.[15]

In June 1976 Bethlehem Steel Corp. at its Bethlehem, Pa., plant charged the new 19-foot, 80 McKee-Otto ovens known as battery "A". The initial coking time of 22.9 hours was extended to 32.0 hours in November 1976.[16]

Bethlehem Steel Corp. at its Lackawanna, N.Y., plant in June started up No. 3 coke-oven battery, bringing the number of coke-oven batteries to six out of seven.[17]

Koppers Co., in September 1976, was considering a $30 million to $40 million expansion plant that would increase its total cokemaking capacity about 35%. The plan involved the construction of 100 additional coke ovens at Woodward, Ala., including 1 60-oven battery and 1 40-oven battery. The expansion would result in an 90% increase in cokemaking capacity at Woodward, which currently has 250 ovens in 3 batteries. Koppers said the new ovens could be operated to produce either foundry coke or blast furnace coke as market conditions dictate, and that existing foundations and auxiliary facilities at Woodward would be utilized.[18]

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[10]Sheridan, E. T. Supply and Demand for United States Coking Coals and Metallurgical Coke. BuMines Spec. Pub., 1976, 23 pp.

[11]Kaufman, C. Shortage of Coke Projected by 85 Unless Nation's Oven Capacity Rises. Amer. Metal Market, v. 84, No. 13, Jan. 19, 1977, p. 3.

[12]Chandler, H. E. Father Hogan: Steel 1976-80. Met. Prog., v. 110, No. 5, October 1976, pp. 33-35.

[13]Coal Outlook. July 22, 1976, p. 2.

[14]Chemical Week. V. 118, No. 21, May 26, 1976, p. 21.

[15]Private Communication.

[16]Private Communication.

[17]American Metal Market. V. 82, No. 112, June 24, 1976, p. 11.

[18]American Metal Market. V. 83, No. 188, Sept. 24, 1976, p. 2.

McLouth Steel Corp., Detroit, Mich., announced on December 22, 1976, that it would purchase the Ironton, Ohio, coke plant of Allied Chemical Corp. The Ironton plant has three oven batteries, one producing foundry coke only, another producing blast furnace coke only, the third, a 24-oven battery provided with pipeline charging, alternately producing both grades of coke.[19]

Mercier Corp., Birmingham, Mich., in early September 1976, announced its intent to purchase the recently closed chemical plant and coke-oven plant of Diamond-Shamrock Corp., Painesville, Ohio. Mercier intended to produce foundry coke for the merchant market. Erie Coke & Chemical Co., a newly formed, wholly owned subsidiary of Mercier, will own and operate the coke facility.[20]

In early May, Republic Steel Corp., Cleveland, Ohio, canceled an $85 million coke-oven order with the Salem Corp. of Pittsburgh, Pa. The coke ovens were originally ordered as part of a $350 million expansion of Republic's Gadsden, Ala., plant; work on the plant was postponed in January 1976.[21]

United States Steel in late 1976, closed the No. 13 coke-oven battery at its Clairton Coke Works as the first step in complying with a consent agreement aimed at reducing air pollution. The closing of the battery caused an immediate loss of 370,000 tons per year of coke and 3.3 billion cubic feet per year of coke-oven gas.[22]

Construction of a new 79-oven coke battery at the Steubenville, Ohio plant of Wheeling-Pittsburgh Steel Corp. was nearing completion with scheduled production starting in the fourth quarter of 1976. The $69 million oven battery, capable of producing 1 million tons of coke annually, is being equipped with proven technology for air and water quality control.[23]

In February 1976, Jones & Laughlin Steel Corp. announced plans for a second 56-oven smokeless coke battery at Aliquippa, Pa., similiar in design to a new $70 million, 56-oven battery that started limited operation in January 1976. The two pipeline-charged batteries will bring coke production at the firm's Aliquippa works back up to 5,700 tons per day.[24]

CONSUMPTION

Apparent consumption of coke (domestic production plus imports, minus exports and changes in stocks) in the United States totaled 56.8 million tons, an increase of 3.15 million tons over that consumed in 1975. The increase was largely attributed to greater demand for blast furnace coke, caused by a 7-million-ton increase in blast furnace pig iron and ferroalloys production.

The amount of breeze-free coke consumed in producing 1 ton of hot metal by blast furnaces decreased from 1,222 pounds in 1975 to 1,188 pounds in 1976.

In 1956, 1,720 pounds of coke was consumed per ton of hot metal produced by blast furnaces. Consumption in 1976 was 532 pounds less than 2 decades ago as a result of the use of increased quantities of iron concentrates, oxygen, and supplemental fuels.

Although a variety of operating practices affect blast furnace coke rates, the 34-pound decrease in the coke rate was accompanied by a 4.4-pound, coke-equivalent increase of supplemental fuels, excluding coal, injected through blast furnace tuyeres per ton of hot metal produced, based on AISI data. The supplemental fuels were principally fuel oil, coal tar and pitch, natural gas, and coke-oven gas. Although the units of measure differ and the quantity of each fuel used varies, the total calorific value of all supplemental fuels consumed in blast furnaces in 1976 was equivalent to 4.46 million of coke. Oxygen consumption in blast furnaces equaled 26,972 million cubic feet, 3.8% more than in 1975. The use of oxygen reduces the blast furnace coke requirement by making available higher temperatures during the reduction of iron ore to pig iron.

Of the 56.8 million tons of oven and beehive coke sold for all purposes, including 2.30 million tons exported, 52.55 million tons went to blast furnaces, 3.01 million tons went to foundries and 1.24 million tons went to other industrial purposes. Steel companies produced 49.15 million tons of blast furnace coke for use in their own blast furnaces. Merchant plants produced 2.80 million tons of blast furnace coke that was sold to blast furnace plants.

Merchant plants produced a total of 4.36

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[19]American Metal Market. V. 82, No. 248, Dec. 23, 1976, pp. 1, 20.

[20]American Metal Market. V. 83, No. 174, Sept. 3, 1976, p. 2.

[21]American Metal Market. V. 82, No. 96, May 1976, p. 4.

[22]American Metal Market. V. 83, No. 3, Jan. 5, 1977, p. 4.

[23]Skillings Mining Review. V. 65, No. 40, Oct. 2, 1976, p. 21.

[24]American Metal Market. V. 83, No. 37, Feb. 24, 1976, pp. 3-21.

million tons of coke, equal to 7.6% of the total oven-coke production. Principal markets were blast furnaces not associated with integrated coke-producing facilities, independent gray-iron foundries, nonferrous smelters, and chemical plants and affiliated foundries. All of the coke produced by beehive plants was sold for blast furnace use. Forty-four States received shipments of coke or breeze in 1976. Illinois, Indiana, Michigan, New York, Ohio, and Pennsylvania, which were the major iron- and steel-producing States, received 75.0% of the total coke and 71.5% of the total breeze distributed.

The bulk of the coke distributed was blast furnace grade and was consumed within the producing State, as most blast furnaces were integrated with coke ovens. A few companies shipped coke to affiliated blast furnaces in other States.

About 5% of the breeze-free coke distributed was shipped to foundries. The chief consumers of foundry coke were the automotive, farm machinery, machine tool, heavy machinery, railroad, and electrical equipment industries. Most of these industries were located in the eastern and midwestern States. The combined receipts of Alabama, Illinois, Indiana, Michigan, New York, Ohio, Pennsylvania, and Wisconsin accounted for 76.3% of the foundry coke shipments. Foundry coke was also shipped to 32 other States, and 166,000 tons were exported.

Other industrial coke was used in 35 States for miscellaneous applications. The principal consumers were nonferrous smelters and plants manufacturing sugar, mineral wool, alkalis, calcium carbide, and elemental phosphorus.

Indiana, Idaho, Missouri, Ohio, and Pennsylvania, received 57.1% of the shipments of other industrial coke.

STOCKS

Yearend stocks of slot-oven coke were 29.8% more than at yearend 1975, with the quantity of coke in stock increasing to 6.49 million tons during 1976. Oven-coke plants ended the year with stocks equal to 42.4 days' production at the December 1976 rate. Normally, beehive plants do not stock coke.

The bulk of the stock, 95.1%, was at furnace plants, which roughly had a 43.5 day supply, compared with 28.5-day supply at merchant plants. There were no producers' stocks of beehive coke at yearend 1976.

Stocks of coke breeze at producers' plants increased 9.6% during 1976. Approximately 82.1% of the breeze in stock was at furnace plants.

VALUE AND PRICE

The average value of receipts of all grades of oven coke was $94.35, up $6.71 per ton, 7.7%; beehive coke averaged $72.48, up $7.57 per ton, or 11.2%.

For oven coke, an increase of 7.4% raised the average price of foundry coke sales to $114.45 per ton, and commercial sales to blast furnaces increased an average of 7% to $78.84 per ton. Oven coke used for other industrial purposes increased 3.1% in price to $79.46 per ton.

The differential between the average price of blast furnace and foundry oven coke is attributed to the special specifications for foundry coke, which make it a more costly product, and to its superior properties resulting from long coking times at lower temperatures of coal mixtures containing up to 50 weight-percent low-volatile coal and anthracite, and occasionally petroleum coke, and milled coke dust.

The average price of foundry coke in the United States remained fairly constant throughout much of 1976, with no significant trends. The difference in the average values of oven and beehive cokes is partially due to the additional transportation costs of coal delivered to oven-coke plants, and the substantial investment and maintenance costs of slot-type ovens.

The price of domestic blast furnace coke remained in the range of $78.80 to $85.00 per short ton.

FOREIGN TRADE

Foreign trade in coke was slower than in 1975. Exports, at 1,314,725 tons, were 41,819 tons more than in 1975 and amounted to 2.25% of total production. Of the total coke exported to more than 21 countries, approximately 70.5% went to Canada and the Netherlands at an average price of $47.69 per ton. Exports from Buffalo, N.Y., Detroit, Mich., Norfolk, Va., Philadelphia, Pa., Cleveland, Ohio, Chicago, Ill., and Laredo, Tex., totaled 1,179,428 tons at an average price of $49.68 per ton. Total exports averaged $50.75, per ton, or $7.96 per ton less than in 1975. Canada received 754,433 tons or 57.4% of the total exports. Exports to Canada averaged $48.73 per ton.

Imports of coke totaled 1,311,472 tons and averaged $84.69 per ton, compared with 1,818,981 tons imported in 1975 at $86.03 per ton. Canada, Belgium-Luxembourg, France, and West Germany together shipped 1,250,192 tons at $86.23 per ton to the United States. West Germany alone shipped 891,105 tons averaging $93.61 per ton. Buffalo, N.Y., Detroit, Mich., New Orleans, La., and Chicago, Ill., were the major ports of entry for 1,207,256 tons having an average price of $86.17 per ton.

Despite more-than-adequate inventories, an upturn in world coke trade and price was foreseen because the Government may mandate further coke oven shutdowns in the United States. The prediction was that the U.S. buyers would augment coke supplies by foreign purchases, as a hedge against this possibility.

COKING COALS

QUANTITY AND VALUE OF COAL CARBONIZED

A total of 84.3 million tons of bituminous coal was carbonized at high temperatures for the production of coke in slot-type and beehive ovens. This quantity, equaling 12.4% of the 1976 U.S. bituminous coal production, was the second largest coal market. In addition to bituminous coal, 380,000 tons, or approximately 6.1%, of the U.S. anthracite production was used in the coal blends carbonized. Anthracite was used principally in the production of foundry coke to achieve greater size and density, which are desirable properties during the operation of foundry cupolas.

The average delivered value of all coal and anthracite carbonized by oven-coke plants was $44.16 per ton. The average value of coal carbonized by beehive-coke plants cannot be published because of individual company confidentiality. Transportation costs account for the high value of the coal consumed by oven-coke plants in some States.

The average value per ton of bituminous coal and anthracite carbonized at oven-coke plants was 5 cents per ton less than in 1975. The highest coal price recorded was in Maryland and New York, where the value of coal carbonized averaged $56.65 per ton, or 62 cents less per ton than in 1975.

An overall average of 1.45 tons of coal, valued at $64.03, was required for each ton of oven coke produced. Beehive ovens required an average of 1.57 tons of coal per tons of coke output.

BLENDING

It is difficult to define a "good coking coal." Gradually, the word "good" is being replaced by "satisfactory," which means that a coal or blend of coals produces a coke that permits a blast furnace practice fully competitive in quality, efficiency, and cost. It is only rarely that a single coal is available for making a satisfactory coke; blending of two or more coals having different properties is the rule at the majority of coke plants. While a two-coal blend of high- and low-volatile coals is most common, there are cases in which the use of a third coal or other blending material is advantageous. In certain locations and with similar types of coals, coal tar pitch, petroleum coke, milled coke dust, and other carbonaceous materials have been tried and in some cases have been used commercially with success.

The terms "low-," "medium-," and "high-volatile coking coals" do not designate sharply defined classes. These terms are used by slot-oven operators in a relative sense and the exact meanings intended by the individual operator may vary somewhat with the behavior of the coals with which he is best acquainted, or which are available for his plant.

The term "low-volatile coal" is used in this publication to designate coals of 14% to 22% volatile matter (dry basis), such as the Pocahontas and New River, W. Va., and Somerset County, Pa., type. For byproduct oven use, such coals are mixed with high-volatile coking coals in any proportion up to 60% or more (but usually from 10% to

30%), to increase the size and strength of the coke. This practice increases the coke yield and decreases the byproduct yields. Most slot-oven operators prefer low-volatile coals having a volatile matter content of about 16% to 18% (dry basis), although a considerable quantity of coal that is not within this range is used. Low-volatile coals are not charged in an unmixed condition into slot-ovens because they expand when coked.

The Bureau defines medium-volatile coking coals as those having 22% to 31% volatile matter (dry basis). Such coals have certain coking characteristics that differentiate them from coals having distinctly higher or lower volatile-matter content. The medium-volatile coal, when coked without admixture, nearly always produce large blocky cokes having highly desirable general physical characteristics. Many medium-volatile coals, particularly those having less than 24% to 25% volatile matter, are practically nonshrinking, or even slighty expanding under many operating conditions, in which cases the coke would be difficult or impossible to push from the slot oven.

The largest portion of the tonnage of all coals charged into slot ovens exceeds 31% volatile matter (dry basis), and is designated high-volatile coal by the Bureau. High-volatile coking coal is produced from many seams in many States. Because high-volatile coals, when carbonized alone, produce lower yields of weaker and smaller sized coke, many plants producing blast furnace coke add low- or medium-volatile coals to high-volatile coals to the extent of 10% to 30% of the weight of coal mixtures charged into the slot-type ovens. The use of anthracite imparts increased size and density and the use of tar pitch in the coal mix increases the coke strength.

Blending also permits the use of some high-sulfur-content coals in admixture with low-sulfur coals so that the coke has an acceptable sulfur content.

The overall percentages of high-, medium-, and low-volatile coals in the mixtures carbonized have varied little in the past decade, although there are wide variations in the proportions used by individual plants. Coke plants in West Virginia and the Western States used the largest percentage of high-volatile coals in their blends, while plants in Minnesota and Wisconsin used the largest percentages of low-volatile coals. Compared with furnace plants, some merchant plants used approximately 50% of low-volatile coals with anthracite in mixtures carbonized at lower temperatures during a longer coking time to produce foundry coke.

The types of coals used in each plant are determined by the availability of the desired coal, the moisture content, the content and composition of ash-fusion temperature, volatile matter content, expansive properties, delivered cost, storage characteristics, free-swelling index (FSI), and the physical and chemical properties of the coke product.

SOURCES OF COAL

Of the 26 States that produced bituminous coal in 1976, 14 States shipped coal to coke plants, supplying 84,899 million tons of coals for coking. Of these shipments, 66.1% were high-volatile coals and 13.0% and 120.9% were medium- and low-volatile coals, respectively.

Of the coals received by oven-coke plants, 76.8% were produced in West Virginia, eastern Kentucky, and Pennsylvania; 69.3% were high-volatile coals. West Virginia shipments comprised low-volatile coals from McDowell, Raleigh, and Wyoming Counties and medium-volatile coals from Fayette, Logan, Mingo, and Nicholas Counties. Pennsylvania supplied high-volatile coals from Allegheny, Greene, and Washington Counties and low-volatile coals from Cambria and Somerset Counties. Pennsylvania and West Virginia coals were widely distributed and used in many of the coke-producing States. Eastern Kentucky supplied 13.7% of the shipments to coke plants, all of which were high-volatile coals produced mainly in Floyd, Harlan, Letcher, and Pike Counties.

Illinois produced high-volatile coking coals, principally in Franklin and Jefferson Counties; other States with substantial production were Alabama, Colorado, Utah, and Virginia. Most of the coal produced in these States was used within the State. Colorado, New Mexico, and Utah, however, supplied most of the coals that were carbonized in California.

Inland Steel Co. identified a large deposit of high-volatile coal for possible future deep-mine development near Marshall, Clark County, Ill. Tentative estimates indicate more than 200 million tons of commercially recoverable coal. The discovery was made on lands under lease to an Inland subsidiary, Northern Mining Inc. The tract explored covers 80,000 acres. Additional testing and drilling will be required to determine the quality and confirm the preliminary reserve estimates. Inland also had extensive coking coal reserves at Sesser and McKeansboro in southern Ill.[25]

Wheeling-Pittsburgh Steel Corp. had a 20% participation in the $50 million Scotts Branch mine project in Kentucky, managed by Pickands Mather & Co. By late 1976, coal production had started and the cleaning plant was nearly completed. The facility will have an annual capacity of 1.25 million tons of coking coal.[26]

In November 1976, Wheeling-Pittsburgh Steel Corp. announced plans for a $27 million expansion, to boost by 81% the annual production of high-volatile coking coal at its Omar mine near Charleston, W. Va. The expansion, when completed 3 years later, is expected to increase capacity from 500,000 tons in 1976 to 908,000 tons annually; the productive life of the mining complex will have been increased by at least 21 years. The Omar mine will be a principal source of high-volatile coals needed for the firm's coke batteries at Follansbee, W. Va., where a new $67 million coke battery was scheduled to go into production in early 1977.[27]

Inland Creek Coal Co. reached the Pocahontas No. 3 seam, located 1,350 feet below the surface of Buchanan County, W.Va., after a March 1976 cost sharing agreement with the Nation's largest independent foundry coke producer, Alabama By-Product Corp., (ABC). The mine is expected to produce 1 million tons per year. For its share in the $45 million project, ABC had the right and obligation to take one-third of the mine's production with options for additional tonnage. Presently, ABC gets its low-volatile coal from West Virginia sources. The firm's decision to continue going outside Alabama to assure its future low-volatile coal requirements reflects on the quality of coal expected from deep mines being developed in Alabama.[28]

CAPTIVE COAL

About 53.2% of the coal received by all slot-oven plants was produced by company-owned or affiliated mines. Ordinarily, this captive coal does not enter commercial channels. In 1976, 54.2% of the coal received by furnace-coke plants was captive. Some merchant plants also owned coal mines, but only 38.8% of the coal received was captive production.

STOCKS

Stocks of bituminous coal at slot-oven plants ranged from 7.26 million tons to 11.26 million tons, equal to 32 and 50 days' consumption, respectively, at the yearly daily average of 228,860 tons. Bituminous coal stocks reached their highest yearly level during June when month-end quantities totaled 11.26 million tons. The lowest level, 7.26 million tons, was reported at the end of August.

Bituminous coal stocks at yearend 1976 were 9.8 million tons, compared with 8.67 million tons when the year began. The 9.8 million tons in stock at all slot-oven plants at yearend was equal to a 44-day supply at the December 1976 rate of consumption.

Stocks of anthracite at yearend totaled 98,000 tons, which was equal to a 94-day supply at the 1976 average rate of consumption.

COAL CHEMICALS

The term "coal chemicals" refers to the refined materials recovered from the crude liquids obtained from the gases and vapors released during coal carbonization. Three materials—ammonia, tar, and light oil—are normally recovered at slot-oven plants using condensation and absorption processes. The remaining noncondensible material, which is rich in hydrogen and methane, is called coke-oven gas. Except for ammonia, which is recovered as an aqueous solution, or an ammonium sulfate or phosphate and sold as produced, the materials are in most instances further processed to yield a number of primary organic chemicals or chemical mixtures, the most important of which are benzene, toluene, xylenes, solvent naphtha, crude chemical oil (better known as carbolic oil), and pitch. Although many slot-oven plants in the United States are equipped to process tar and crude light oil, the extent to which such equipment is utilized depends upon economic conditions and tonnage of coal carbonized because

[25] Skillings Mining Review. V. 65, No. 48, Nov. 27, 1976, p. 19.
[26] American Metal Market. V. 82, No. 228, Nov. 23, 1976, p. 2.
[27] Work cited in footnote 26.
[28] Coal Week. April 1976, p. 3.

yields of various chemicals are low.

Yields of chemicals vary with the kinds of coals carbonized, carbonizing temperatures, and operating techniques and equipment. About 315 pounds of coke-oven gas, 76 pounds of tar, 18.7 pounds of crude light oil, and 5 pounds of ammonia were recovered for each short ton of coal carbonized. In standard units of measure, these quantities amount to 11,063 standard cubic feet of coke-oven gas, 7.6 gallons of tar, and 2.55 gallons of crude light oil. Ammonia expressed as ammonium sulfate equivalent was recovered at an average rate of 15.64 pounds per ton of coal carbonized in those 51 plants employing recovery processes.

In terms of calorific value, the products recovered by oven-coke plants (excluding coke) in 1976 totaled 628.4 trillion Btu. This quantity was roughly equivalent to 31.3% of the heating value of the coal carbonized. In deriving the total calorific value of the products recovered, coke-oven gas was based on 550 Btu per standard cubic foot, crude coal tar, 160,000 Btu per gallon; and crude light oil, 125,000 Btu per gallon. Coal as charged to coke ovens was assigned a calorific value of 24 million Btu per ton.

COKE-OVEN AMMONIA

Coal carbonized at high temperatures releases nitrogen and hydrogen parts of which combine to produce ammonia. Ammonia must be removed from coke-oven gas to reduce the subsequent formation of corrosive compounds with oxygen, hydrogen sulfide, and hydrogen cyanide. Coke-plant operators normally recover ammonia as an aqueous solution, or as ammonium sulfate or phosphate. However, 10 plants did not recover ammonia as a salable product in 1976.

Production of ammonia increased 1% although the number of recovery plants decreased by one. The average value of ammonium sulfate decreased from $78.07 per ton in 1975 to $48.72 in 1976, and the value of ammonia liquor increased from $92.75 per ton in 1975 to $93.67. The total value of all sales decreased 11%. Ammonia products sold in 1976 represented 3.2% of the total value of all coal-chemical sales.

The new coke oven plant of Armco Steel Corp., Middletown, Ohio, used a system developed by Firma Carl Still of West Germany to recover hydrogen sulfide from coke-oven gas as a feedstock for sulfuric acid production. Another system, developed by United States Steel Corp., recovers ammonia vapor and converts it to an anhydrous product. In this system, vapors evolved from the ammonia still contain H_2S, NH_3, CO_2 and HCN that, after removal of NH_3 by absorption in cold water, are finally burned in the combustion chamber of the sulfluric acid plant. Armco's Middletown plant will produce about 54 tons per day of 66° Be acid. The heat generated during the conversion steps generates 600-pounds per square inch steam.[29]

COKE-OVEN GAS

The fixed gases resulting from the carbonization of coal have a gross heating value ranging from 520 to 600 Btu per standard cubic foot, and are principally used for heating coke ovens and steel- and allied-plant furnaces. Small volumes were sold for distribution through city mains and for minor industrial uses. Gas yields vary among plants but the average quantity produced for each ton of coal carbonized in all slot ovens was 11,063 cubic feet, compared with the average yield of 10,860 cubic feet for 1975. The total gas production increased 1.90% because 1.55% more coal was carbonized in 1976.

About 39.54% of the coke-oven gas produced was used for heating ovens. Most of the remainder of the production was used by coke producers to fuel boilers or transferred to steel or allied plants to heat open-hearth and other metallurgical furnaces. A small part of the gas produced was flared in situations where production exceeded demand.

Although coke-oven gas was the principal fuel used to heat coke ovens in 1976, some ovens were heated by a mixture of coke-oven and blast furnace gas, or mixtures containing blast furnace and natural gas. A total of 401.6 billion cubic feet of coke-oven gas equivalent was so consumed, of which about 89.8% was coke-oven gas.

Surplus coke-oven gas used and sold in 1976 was valued at $402.120 million, a 37.4% increase from the 1975 value. No value was reported by producers for the coke-oven gas used to heat their ovens, but by applying the average value of $0.747 per thousand cubic feet reported for surplus gas to the gas used for underfiring, the total value of all coke-oven gas used and sold in 1976 would be $671.2 million.

COAL TAR AND DERIVATIVES

All oven-coke plants produced crude tar in quantities ranging between 3.79 and 9.17

[29]Colaianni, L. J. Coke-oven Gas Yield Fuel, Chemical Byproducts. Chem. Eng., v. 83, No. 7, Mar. 29, 1976, pp. 82, 83.

gallons per ton of coal carbonized. Coke plants in California, Colorado, Utah, Ohio, and Pennsylvania had the larger yields of tar, ranging from 9.17 gallons to 7.98 gallons per ton of coal carbonized.

The average tar yield was down 2.9%, and the production was 1.4% less than in 1975.

Coke-plant operators consumed 55.9% of the crude tar produced. Of this quantity, 45.8% was processed (refined or topped) and 52.7% was burned as fuel without any processing. The remaining production, together with withdrawals from stock, was sold to tar-distilling plants for refining into a variety of tar-derived products.

Most of the crude tar that was processed in 1976 was subjected to topping, whereby distillate fractions, consisting mainly of low-boiling tar acids and bases, and naphthalene were obtained. The resulting residue (called soft pitch) was usually used for fuel. Furnace coke plants that were integrated with steel plants in particular benefitted from this situation because they sold the distillate and retained the soft pitch for use as fuel. However, the relative quantities of tar topped, burned, or sold, depend on the availability and current market prices of crude tar, tar distillates, and other substitute fuels. Most of the merchant plant tar production was sold because merchant plants had little demand for pitch, which normally represented 65 to 92 volume-percent of the crude tar feed to the topping stills.

Most of the plants that processed crude tar recovered only crude chemical oil (also known as carbolic oil) and liquid still residues ranging up to soft pitch. Some of the larger plants recovered a number of tar-based products, including cresote oil, cresylic acid, cresols, naphthalene phenols, xylols, pyridine, picoline, quinoline, and medium and hard pitch. Although statistics on many of these tar derivatives are not disclosed in this report because of company confidentiality, the data were transmitted to the U.S. Tariff Commission for publishing with similiar data from tar distillers and petroleum refiners, in monthly and annual reports on synthetic organic chemicals.

CRUDE LIGHT OIL AND DERIVATIVES

Crude light oil is a mixture of aromatic hydrocarbons, thiphene, mercaptans, hydrogen sulfide, and carbon disulfide that are absorbed from the coke-oven gas after tar, ammonia, and in some instances, naphthalene have been removed. Crude tar contains an insignificant content of crude light oil that is seldom recovered at coke plants. Practically all crude light oil produced at coke plants is recovered by absorption, in which the gas is contacted with a high-boiling petroleum oil or a coal-tar-based distillate as the gas passes through absorption equipment. Crude light oil is stripped from the absorption oil by direct steam distillation. About 1.7 to 3.1 gallons (12.5 to 22.7 pounds) of crude light oil was recovered per ton of coal carbonized. Yields vary with the kinds of coal carbonized and with operating conditions. An average of 2.53 gallons per ton of coal carbonized was recovered at 51 plants that extracted light oil in 1976. Yields per ton of coal were about the same as 1976 levels in both merchant and furnace plants. Ten plants left the light oil in the gas to increase its calorific value.

Producers refined 45.4% of their crude light oil output. The increase of crude light oil sales in recent years is attributed to the inability of some plants to produce derivatives meeting the rigid specifications of dependable quality and competitively priced aromatic petrochemicals. Such plants sell crude light oil to petroleum-refining companies for processing with petroleum-derived fractions into benzene, toluene, and a number of other chemical intermediates.

As with other coal-chemical materials, yields of products derived from crude light oil vary, but about 79.1 volume-percent of the crude light oil processed was recovered in 1976 as salable products, comprising 58.8% as benzene, 10.6% as toluene, 1.8% as xylene, and 7.9% as solvent naphtha and other light oil products. All of the benzene production was classed as specification grades. In past years, a large amount of motor-grade benzene was used to increase antiknock properties of gasoline, but current petroleum-refining practices have all but eliminated this use for benzene.

The unit value of light oil derivatives sold in 1976 ranged from $0.794 per gallon for all grades of benzene to $0.398 per gallon average for all crude and refined solvent naphtha. The average value of all light oil products sold increased 1.3% to $0.706 per gallon, compared to $0.698 per gallon in 1975.

WORLD REVIEW

World production of metallurgical coke in 1976 was estimated at 404.7 million short tons. This quantity is 1.1% more than the 1975 output because of increased production in the U.S.S.R., the United States, Poland, Czechoslovakia, and Belgium.

Europe, with 56.2% of the total, led in world production; European production was 1.3% more than in 1975. Asia, with eight producing countries, ranked second in output with 24.9%. North America, with only three producing countries, ranked third with 16.4%.

Australia.—Nippon Steel Corp. and other major Japanese steel mills contracted to import 6,779 million tons of soft coking from six Newcastle coal mines for fiscal 1976 beginning April 1, 1976. The contract included an increase of 15 Australian cents in price plus an escalation clause permitting an increase of up to $1 (Australian) per metric ton.[30]

Utah International was given conditional approval by the Australian Government for a coking-coal project costing more than $200 million, to be located at Norwich Park, Queensland. The projected capacity was set at 4.5 million tons per year.[31]

Australia's coal export levy was reduced in the Government's Federal budget in August 1976, and is to be completely phased out within 3 years. The decision assures that investments totaling $2.5 billion will be made in coal-mining ventures in the next 5 years. The coal export levy was $7.50 per metric ton.[32]

Canada.—During 1975, approximately 8.2 million tons of coking coal was carbonized in 1,066 slot-type coke ovens, which have the capacity to produce 5.8 million tons of coke from 9.44 million tons of coal. About 90% of the coking coal used in Canada was imported from the United States. Three steel companies in Ontario operated coke-oven plants in Hamilton and Sault Ste. Marie. All had captive U.S. mines and long-term contracts. The Sydney Steel Corp. in Nova Scotia used a blend of Nova Scotia, western Canadian, and imported coals to produce coke for its steel mill. The integrated steelmakers accounted for over 90% of the coke production in Canada.[33]

Emkay Canada Natural Resources, Ltd., a subsidiary of Morris Knudsen Co.; sold a 50% interest in its Elk River coking coal properties in British Columbia for about $3.5 million to Elco Mining Ltd. Projected production capacity is 4 million tons of coking coal per year. Production is expected to begin in 1981 and continue for 28 years.[34]

In early September 1976, Denison Mines Ltd., Toronto, agreed to purchase up to 5 million tons of coking coal per year on a long-term basis, from Quinlette Coal Ltd.[35]

During 1975, most industrialized countries experienced downturns in economic activity that affected the demand for both coking coal and thermal coal through reduced demand for steel and reduced industrial need for electric power. This became evident in Canada toward the latter part of the year. Prices increased during the early part of the year, reflecting both the tight market conditions of 1974 and increased costs. By mid-1975, however, spot prices had fallen sharply as stocks of coal and coke were being built up, and by yearend the situation had not improved. Nevertheless, prices on long-term contracts and for top-quality coals remained firm.

Foreign consumers continued to show interest in western Canadian coking coal deposits, with Japanese, West German, Dutch, and Italian interests taking equity partnerships in potential producing properties in British Columbia.

During the year, the Government of each of the three coal-producing Provinces in western Canada, British Columbia, Alberta, and Saskatchewan, continued studies relating to the development of new coal policies. New legislation was expected to be introduced in 1976 in all three provinces.

In 1975, exports of bituminous coal amounted to 12.9 milllion tons, an increase of 8.5% from 11.9 million tons in 1974. Of total exports, about two-thirds originated from mines in British Columbia, with most of the balance from Alberta. Export shipments accounted for approximately 46% of total coal production and nearly three-quarters of bituminous coal production. Japan received nearly 11.9 million tons, or 92% of exports, compared with 11 million tons or 93% in 1974. Since Canada's exports were

[30]American Metal Market. V. 83, No. 92, May 11, 1976, p. 5.

[31]Industrial Newsletter. May 1976, p. 3.

[32]Coal Age. V. 81, No. 9, September 1976, p. 65.

[33]McMullen, M. K. Coal and Coke. No. 14, 1975. CERP Publication from U. S. Embassy, Ottawa, Canada.

[34]American Metal Market. V. 82, No. 198, Oct. 8, 1976, p. 11.

[35]Coal News. No. 4333, Sept. 10, 1976, p. 4.

mainly coking coal under long-term contracts, Canada's position in international coal trade remained strong even though the international market softened noticeably during the latter part of 1975. In the early part of 1975, Canadian coal producers and their Japanese buyers negotiated new coal prices on the basis of international pricing and abandoned the former basis of "cost plus reasonable profit." The average value of Canadian coking coal exported to Japan in 1975 was $50.00 per long ton, f.o.b. Vancouver.

Germany, West.—A trial production run based on a throughput of 330,000 tons per year of lignite (125,000 tons per year of coke output) was scheduled in August 1976 for the German lignite producer, Rheinische Braunkohlennwerke near Cologne. The lignite degasification was to be done in a hearth-type furnace. The coke product will be used mainly by the German chemical industry as an additive in the processing of lime and phosphate.[36]

Japan.—By late 1976, Mitsui Coke Co., Tokyo, announced its intention to build a 297-short-ton-per-day, semicommercial plant at Omuto, to be completed in October 1979. The plant will employ a new process using asphalt as a solvent for coal dust. The mixture, at 400° to 450°C, yields a pitch that substitutes for hard coking coal. Called Solvolsis, the technique is designed to handle all kinds of Japanese coal dusts, particulary the type produced by the nearby Miike colliery. The plant will also produce about 10,500 thousand cubic feet per day of byproduct gas.[37]

The Pittston Co. concluded the principal elements of a long-term contractual agreement with the six largest Japanese steel producers for purchase of Pittston's medium-volatile, high-fluidity coking coal. The contract will run 12 years, with basic negotiations at 3-year intervals. The quantity of coking coal involved is 10.3 million short tons in fiscal 1977, rising to 10.9 million tons in fiscal 1978 and beyond. Of these quantities, 60% are covered by a basic starting price, $2.05 per short ton more than the current price (not disclosed), plus escalation at agreed-upon intervals. The remaining 40% is subject to price negotiation annually.[38]

Consolidation Coal Co., in October 1976, completed negotiations with six Japanese steelmakers for price increases on its low-volatile coking coal. The agreement calls for the shipment of 1.5 million tons per year of low-volatile coking coal from Consolidation Coal's Pocahontas field in southern West Virginia to Japan until March 31, 1979. Consolidation Coal was to receive a $1-per-long-ton price increase, effective October 1, 1976, and an additional estimated $2.20 per ton in mid-December 1976, to cover cost escalation. Another price increase of $2 per long ton on 1 million tons of this coal was to become effective April 1, 1977. The price for the remaining 500,000 tons was to be at market value of April 1977. The new agreement also provided for the sale of 850,000 long tons of medium-volatile, Rowland-type coking coal to the Japanese customers until March 31, 1980.[39]

Eastern Gas and Fuel Associates, through its export subsidiary, Castner, Curran and Bullitt, Inc., in November announced a tentative agreement with its Japanese customers to supply low-volatile coking coal under new contractual agreements over a 6-year period beginning April 1, 1977. Eastern will supply 750,000 tons per year, with negotiations to be held every 2 years to determine prices and quantities to be shipped. The tentative agreement provides for an increase in the price per long ton, reaching a level of $68.49 by April 1977, on about two-thirds of the coal shipped. The price for the remaining one-third of the coal will be determined on an annual basis as of each April 1. The agreement also includes the right to escalate to cover increased costs.[40]

In March 1976, Pittston Coal Export Co. agreed to lower its price on medium-volatile coal for Japanese steel mills by $1.70 per metric ton to $61.00 per ton f.o.b. for fiscal 1976. The agreement was made on the condition that the Japanese mills would purchase a total of 5.2 million tons during the year and review with Pittston the price situation for the second half of fiscal 1976.[41]

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[36]Chemical Engineering. V. 83, No. 3, Feb. 2, 1976, p. 46.
[37]Chemical Engineering. V. 83, No. 26, Dec. 6, 1976, p. 82.
[38]Coal Age. V. 81, No. 12, December 1976, p. 39.
[39]Coal Age. V. 81, No. 11, November 1976, p. 41.
[40]Coal News. No. 4342, Nov. 12, 1976, p. 4.
[41]American Metal Market. V. 83, No. 42, Mar. 2, 1976, p. 1.

Because of decreased steel demand, Japan was attempting to reduce imports of coking coal from Australia, Canada, the United States, and the Republic of South Africa. Japan's stocks of coking coal were increasing and were expected to exceed 9 million tons in 1976. Japan had total coking coal supply contracts for 64 million tons but on the basis of an estimated 1,102 million tons of steel, 55 million tons of coking coals would satisfy industrial requirements.[42]

In 1976, Nippon Steel Corp. developed an automatic system to quickly and accurately evaluate the coking properties of coal. The system stored the measurement of the reflectance distribution of a coal, as determined by cathode-ray tube, on a disc file.[43]

South Africa, Republic of.—In early March 1976, Nippon Steel Corp. and other Japanese steelmakers reached an agreement with South African coking coal shippers to retain the Witbank coking coal prices for fiscal 1976, beginning April 1. The agreement stemmed from negotiations in which Japanese buyers initially called for a reduction in the past price of $34 per long ton f.o.b., because of a recent accord on a reduction of U.S. coal prices.[44]

The South African Iron and Steel Industrial Corp. (Iscor), in 1976, was developing a new mine for the production of high-grade-blend coking coal near Ellias in the northwestern Transvaal. The mine was expected to start operating in early 1978, and in its first phase of development will produce 1.8 million tons of washed coal annually.[45]

South African experiences with preheated coal operations are described for a coke plant having 66, 13-feet-high coke ovens, two preheaters, and two larry cars. The objectives were to improve the abrasion resistance of the coke; to use more "blend" coal in the oven charge, thus conserving the limited reserves of coking coal; to increase oven throughput 15%; to improve working conditions on the top of the oven batteries; and to obtain a more consistent coal plasticity zone during the coking process.[46]

TECHNOLOGY

Coking coals.—A panel of speakers at the April 1976 meeting of the National Open Health and Basic Oxygen Steel Conference of AIME conceded that steelmakers have become more dependent upon coals with increased ash and sulfur content and decreased fluidity, resulting in less stable and otherwise inferior coke. Decreasing coke stability was reported to relate to about a 0.5% to 1.7% change in iron production per 1.0% change in coke stability. One speaker suggested that purchased coals be processed at captive cleaning plants to produce coals of more uniform composition, thereby eliminating the problem of handling many individual coals at the coke plant.[47]

Petrographic analysis has become the primary tool at Bethlehem Steel Corp. for evaluating purchased and captive coal, evaluating undeveloped coals, resolving operational problems associated with coal composition, and providing compositional control for research projects.[48]

Application of the M-curve, developed by Karl Reinhardt in 1926, can result in substantial reductions in time and labor, compared with other current methods. Venkatesan's analysis shows how the addition of coal dust and/or slurry to the clean coal, or the additional of unwashed coal to a clean coal, increases the yield of coking steam coal to the required ash content. This is done through the use of the M-curve, which does not require the use of mechanical equipment.[49]

It has been shown that the total sulfur

[42]Mining Journal.V. 286, No. 7328, Jan. 13, 1976, p. 73.
[43]Iron and Steel International. V. 49, No. 6, December 1976, pp. 435-436.
[44]American Metal Market. V. 83, No. 45, Mar. 5, 1976, p. 6.
[45]Coal Mining and Processing. V. 13, No. 2, February 1976, pp. 62, 63.
[46]Cooper, D. A., I. Barnes, H. J. Merve, and A. N. Venter. Iron Steelmaker, v. 3, No. 8, August 1976, pp. 29-33.
[47]Peters, H. Panel Says Steelmakers Must Discover Ways to Use Poor Quality Coking Coal. American Metal Market, v. 83, No. 70, Apr. 9, 1976, p. 3.
[48]Thompson, R. R., and L. G. Benedict. Coal Composition and Its Influence on Coke Making. Iron and Steelmaking, v. 3, No. 2, February 1976, pp. 21-31.
[49]Venkatesan, S. Use of M-Curve Predicts Washing Properties of Coal. Coal Age, v. 81, No. 6, June 1976, pp. 108-111.

lost when coking coal and limestone mixtures decreased and the percentage of FeS, originating from the disassociation of pyrite, and conversion to CaS, increases as the amount of lime added increases. Although the total sulfur content of coke produced in the presence of CaO is higher than when the coal is coked without lime, the pyrite sulfur is converted to CaS, which is more amenable to chemical conversion to H_2S. A method is outlined for determining CaS in the coked mixture in the presence of FeS.[50]

Coal ash, sulfur, and coking properties have effects on the coke produced, which, in turn, affects blast furnace performance. Analyses of blast furnace data for a given plant established relationships between coke properties and furnace output. The relationships of new tons per day of hot metal production were shown by equations.[51]

By mid-1976, Armco Steel Corp. at its Ashland, Ky., plant was able to replace as much as 18% of the Amanda furnace's coke requirements and 28% of the coke requirements of the Bellefonte furnace with pulverized coal.[52] Pulverized coal injection into the Amanda furnace has enabled Armco to reduce ironmaking costs in this furnace by $2.85 per ton based on 100,000 tons of hot metal production per month. Using metallurgical coal for injection, Armco was able to replace 1.1 pounds of coke per pound of coal injected. When injecting higher ash, nonmetallurgical coals, 0.78 pound of coke was replaced per pounds of such coal injected.[53]

Frank W. Luerssen, Vice-President of Research at Inland Steel Corp., stated that there has been adequate demonstration that preheating coal charged to coke ovens is one approach to enable the steel industry to use a higher proportion of more plentiful coals. Mr. Luerssen made it clear that pioneering work in the field of coal and coke involves great expense and much time in development activity.[54]

A new test procedure to determine the reactivity of coke was developed that overcomes the shortcomings of conventional testing methods. The rate of reaction between CO_2S and carbon was found to be dependent on the rate of CO_2 flow through the coke bed. Using this method, the reactivity of 13 samples of coke from many different coal ranks, chars, and briquettes was determined.[55]

Eastern Associated Coal Corp. at Everett, Mass., in work done for Bethlehem Steel Corp. and the American Iron and Steel Institute, performed Micum Drum tests to determine the physical strength on a shipment of Russian coke. The Everett, Mass., Research Center has the only full Micum Drum in the United States that can be used for the Micum tumbler test.[56]

Bethlehem Steel Corp. and Inland Steel Corp. requested detailed information from the Sumitomo Metal Industries, Ltd., on two Sumitomo processes for producing coke partly and wholly from noncoking coal. The Sumicoal system reportedly was designed to produce coke in a conventional coke oven from coking coal and briquettes made by blending noncoking coal, coking coal, asphalt, and pitch, whereas Sumitomo's formed-coke system produces coke solely from noncoking coal in a specially developed coke oven.[57]

Coke ovens.—The Illinois State Geological Survey conducted more than 100 tests on coals and coal blends that were preheated before they were charged into a 700-pound pilot coke oven. The preheater used was of simple design and proved to be satisfactory for the test program. The test results indicated that preheating caused a consistent decrease in time required for complete carbonization. Coke strength, as measured by the ASTM Tumbler Test, was not materially affected by preheating coal blends, which produced stabilities in the mid-1950's, when they were charged without preheating. However, preheating resulted in a material increase in stabilities of

[50]Brothers, J. A., and J. Starzomski. Reaction of Pyritic Sulfur in Coal with Lime and Calcined Dolmite the Coking Process. Fuel, v. 55, No. 2, April 1976, pp. 105-108.

[51]Ostrowski, E. J. Coke Quality - Its Effect on the Blast Furnace. AIME Ironmaking Proc., v. 35, 1976 pp. 289-293.

[52]American Metal Market. V. 83, No. 113, June 9, 1976, p. 4.

[53]American Metal Market. V. 83, No. 122, June 22, 1976, p. 3.

[54]Luerssen, F. W. Development of Coking Technologies Reviewed. Coal Age, v. 82, No. 1, January 1977, p. 41.

[55]Banejee, N. C., P. K. Mitra, K. Raja, and D. K. As. Method for the Determination of Reactivity of Coke. J. Mines Met. Fuels, v. 24, No. 6, June 1976, pp. 206-209.

[56]Coal Mining and Processing. V. 14, No. 1, January 1977, p. 24.

[57]The Japan Echo. V. 5, No. 3582, Dec. 23, 1976, p. 1.

the cokes from poorer coking coals. Other physical properties of the cokes were not greatly affected. The rapid evolution of gas when preheated coals were carbonized proved to be a major problem that was not completely solved.[58]

A preheated coal-pipeline-charging system is described that overcomes one of the major pollution sources at coke plants. One advantage of the system is that the coal enters the ovens through a closed, stationary network so that dust cannot escape. This is a major consideration because it has been estimated that as much as 70% of all coke-oven emissions occur during oven charging.[59]

The input fuel gas for heating any oven battery increases as coking rates increase within the normal range of coking operation. Pushing higher temperature coke to minimize emissions increases the fuel gas requirement. The combination of fast coking rate and higher coke temperature results in a higher fuel-gas temperature, which also increases the fuel-gas requirement. High coal moisture increases the fuel-gas requirement. Large amounts of excess combustion air, which is necessary under certain conditions, also increases the fuel-gas requirement. Waste-gas temperature can be controlled by regenerator design so that it does not increase the fuel-gas requirement. The properties of the coal mix determine the net exothermic heat of reaction within the coal charge and have a substantial effect on the fuel-gas input. Because of the many variations in operating conditions and properties of the coal mix it is impossible to make a meaningful guarantee of the full gas input to modern coke oven.[60]

Some experimental coke ovens of Bergbau-Forschung GmbH at the Ruhrkohle AG central coking plant at Prosper, West Germany, were lined with magnesite bricks. However, according to a U.S. observer, the magnesite liners were a complete failure because of uncontrolled expansion and contraction.[61]

In October 1976, Bethlehem Steel Corp., Republic Steel Corp., and Inland Steel Co. announced that each has purchased a new enclosed one-spot, coke-pushing system from Koppers Co., Pittsburgh, Pa. Each unit, costing about $3 million to $3.5 million, is designed to control emissions released during the pushing of hot coke from coke ovens. Apparently, the interest of the three steel producers stemmed from results achieved with a similiar Kopper's product at the Weirton Steel Div. of National Steel Corp.[62]

The Colorado Air Pollution Variance Board in November 1976 approved plans furnished by the CFI Steel Corp. to change its method of controlling coke-oven emissions while ruling that the project must be completed by October 15, 1979. The new method, estimated to cost $6 million, will provide for collection of particulates emitted from 143 ovens by a hood installed over the coke ovens.[63]

The Granite City Steel enclosed one-spot, coke-pushing control system comprises four major units, as follows: Enclosed coke guide; enclosed coke receiver; evacuation and gas-cleaning car; and conventional coke quench tower with modified water piping. With this system, any smoke or fumes that emanate from the oven-pushing and transfer of the hot coke to the quench tower are collected and passed through a high-energy venturi scrubber prior to discharge to the atmosphere.[64]

The Chemico enclosed, coke-quench, car-emission-control system appears to have replaced the coke-side shed system that was developed in 1973. Reportedly, the Chemico system, which does not need a hood-enclosure seal, is guaranteed to meet both Federal and State emission control standards.[65]

The British Steel Corporation has ordered 2,000 new combined respirator and safety

[58]Helfenstine, R. J. Charging Preheated Coals Into a Pilot Coke Oven. AIME Ironmaking Proc., v. 35, 1976, pp. 440-449.

[59]McManns, G. J. Pipeline Charging Scores for Cleanliness. Iron Age, v. 217, No. 9, Mar. 1, 1976, pp. MP9-MP12.

[60]Grosick, H. S., E. J. Helms, and J. M. Airgood. Iron Steel Eng., v. 53, No. 5, May 1976, pp. 27-32.

[61]Ironman, R. International Report. Coal Min. and Proc., v. 14, No. 1, January 1977, p. 48.

[62]American Metal Market. V. 82, No. 203, Oct. 15, 1976, p. 3.

[63]American Metal Market. V. 82, No. 230, Nov. 23, 1976, p. 8.

[64]Manda, J. G. Enclosed Coke Pushing Controls. Iron and Steelmaker, v. 3, No. 8, August 1976, pp. 24-28.

[65]33 Magazine. Enclosed Coke-Quench Cars Gain Ground as Method of Cleaning Oven-Push Emissions. V. 14, No. 10, October 1976, pp. 38-40.

helmets, each having a fan that directs clean, filtered air across the wearer's face under conditions of fumes or dust. The first helmets will be provided as part of a package of improvements for protecting the health of coke-oven operators. The original prototype of the helmet was designed by the Safety in Mines Research Establishment. Racal-Amplivoc Communications, Ltd., Wembley, Middlesex, cooperated closely during the development of the helmet.[66]

A sealing device for use in charging coke ovens is described in British Patent 1,391,881. The bottom face of the telescopic charging sleeve on each charging-car hopper has a part-spherical surface that mates with a sealing ring to form a ball-and-socket joint. The ring is resiliently mounted on lugs on the sleeve and its position relative to the axis of the sleeve can be adjusted. The arrangement allows a smoke-tight connection to be made with displaced or tilted chargehole frames.[67]

Coke plant water pollution.—Researchers at ERDA's Oak Ridge National Laboratory developed a process that uses microscopic organisms to destroy phenolics in aqueous wastes of coke plants and coal conversion facilities. The process uses a vertical, tapered column containing pulverized coal suspended in the waste water. By substituting different kinds of microorganisms, the same process can be used to remove ammonia, nitrates and other organic compounds.[68]

Republic Steel Corp.'s research department conducted extensive laboratory, semipilot plant, and pilot plant studies in an effort to control coke-plant major process streams. Pollution problems, resulting from coke plants include crude ammonia liquor, barometric condenser water from ammonium sulfate crystallizers, and interception sump water from conventional light oil refining plants. Studies resulted in the development of a modular system to treat waste water.[69]

Coke plant wastewater sources, energy requirements for wastewater treatment, effluent limitations for selected coke plant pollutants, and cross-media analysis are discussed.[70]

[66]Steel Times. Protecting Health of BSC Coke-Oven Operators. V. 204, No. 12, December 1976, p. 1015.
[67]BCRA Review. V. 2, No. 3, July-September 1975, p. 204.
[68]Compressed Air Magazine. V. 81, No. 10, October 1976, p. 21.
[69]Schroeder, J. W., and A. C. Naso. A New Method for Treating Coke Plant Waste Water. Iron Steel Eng., v. 53, No. 12, December 1976, pp. 60-66.
[70]Dunlap, R. W., and F. C. McMichael. Reducing Coke Plant Effluent. Environ. Sci. and Technol., July 1976, pp. 654-657.

Table 2.—Statistical summary of the coke industry in the United States in 1976

	Slot ovens	Beehive ovens	Total
Coke produced:			
At merchant plants ____ thousand short tons__	4,363	(1)	(1)
At furnace plants[2] ____ do____	53,365	(1)	(1)
Total____ do____	57,728	605	58,333
Breeze produced ____ do____	4,342	--	4,342
Coal carbonized:			
Bituminous:			
Thousand short tons ____	83,383	941	84,324
Value (thousands) ____	$3,681,468	W	W
Average per ton ____	$44.15	W	W
Anthracite:			
Thousand short tons ____	380	--	380
Value (thousands) ____	$17,634	--	$17,634
Average per ton ____	$46.41	--	$46.41
Total:[3]			
Thousand short tons ____	83,764	941	84,704
Value (thousands) ____	$3,699,102	W	W
Average per ton ____	$44.16	W	W
Average yield in percent of total coal carbonized:			
Coke ____	68.92	64.29	68.87
Breeze (at plants actually recovering) ____	5.12	--	5.12

See footnotes at end of table.

Table 2.—Statistical summary of the coke industry in the United States in 1976 —Continued

	Slot ovens	Beehive ovens	Total
Coke used by producing companies:			
In blast furnaces:			
Thousand short tons	49,147	607	49,754
Value (thousands)	$4,179,662	$43,996	$4,223,658
In foundries:			
Thousand short tons	167	--	167
Value (thousands)	$18,417	--	$18,417
For other industrial uses:			
Thousand short tons	326	--	326
Value (thousands)	$27,506	--	$27,506
Breeze used by producing companies:			
In steam plants:			
Thousand short tons	197	--	197
Value (thousands)	$4,532	--	$4,532
In agglomerating plants:			
Thousand short tons	1,363	--	1,363
Value (thousands)	$40,880	--	$40,880
For other industrial uses:			
Thousand short tons	838	--	838
Value (thousands)	$27,655	--	$27,655
Coke sold (commercial sales):			
To blast furnaces:			
Thousand short tons	2,801	--	2,801
Value (thousands)	$220,823	--	$220,823
Average per ton	$78.84	--	$78.84
To foundries:			
Thousand short tons	2,840	--	2,840
Value (thousands)	$325,030	--	$325,030
Average per ton	$114.45	--	$114.45
To other industrial plants:			
Thousand short tons	910	(4)	910
Value (thousands)	$72,311	(4)	$72,311
Average per ton	$79.46	(4)	$79.46
For residential heating:			
Thousand short tons	(5)	--	(5)
Value (thousands)	(5)	--	(5)
Average per ton	(5)	--	(5)
Breeze sold (commercial sales):			
Thousand short tons	1,846	--	1,846
Value (thousands)	$60,112	--	$60,112
Average per ton	$32.56	--	$32.56
Coal-chemical materials produced:			
Crude tar:			
Thousand gallons	636,382	--	636,382
Gallons per ton of coal	7.60	--	7.60
Ammonia:[6]			
Thousand short tons	539	--	539
Pounds per ton of coal	15.64	--	15.64
Crude light oil:			
Thousand gallons	198,056	--	198,056
Gallons per ton of coal	2.53	--	2.53
Gas:			
Million cubic feet	912,399	--	912,399
Thousand cubic feet per ton of coal	10.89	--	10.89
Percent burned in coking process	39.54	--	39.54
Percent surplus used or sold	59.01	--	59.01
Percent wasted	1.45	--	1.45
Value of coal-chemical materials used or sold:			
Crude tar and derivatives:			
Used ... thousands	$242,118	--	$242,118
Sold ... do	$139,337	--	$139,337
Ammonia products[7] ... do	$29,066	--	$29,066
Crude light oil and derivatives[8] ... do	$107,193	--	$107,193
Surplus gas ... do	$402,120	--	$402,120

W Withheld to avoid disclosing individual company confidential data.
[1]Not separately recorded.
[2]Plants associated with iron blast furnaces.
[3]Data may not add to totals shown because of independent rounding.
[4]Included with beehive coke sold "to blast furnace plants" to avoid disclosing individual company confidential data.
[5]Included with "To other industrial plants" to avoid disclosing individual company confidential data.
[6]In terms of sulfate equivalent.
[7]Includes ammonium sulfate, ammonia liquor, and diammonium phosphate.
[8]Includes intermediate light oil.

Table 3.—Summary of oven-coke operations in the United States in 1976, by State

State	Plants in existence Dec. 31	Coal carbonized (thousand short tons)	Yield of coke from coal (percent)	Coke produced (thousand short tons)
Alabama	7	6,588	70.77	4,662
California, Colorado, Utah	3	5,085	63.74	3,241
Illinois	4	2,771	61.57	1,706
Indiana	6	12,267	67.33	8,259
Kentucky, Missouri, Tennessee, Texas	5	1,913	69.84	1,336
Maryland and New York	4	8,952	70.83	6,341
Michigan	3	4,782	70.95	3,393
Minnesota and Wisconsin	3	986	72.62	716
Ohio	11	12,192	69.14	8,430
Pennsylvania	12	23,033	70.23	16,175
West Virginia	3	5,195	66.78	3,469
Total in 1976	61	83,764	68.92	57,728
At merchant plants	13	5,874	74.28	4,363
At furnace plants	48	77,890	68.51	53,365
Total in 1975	62	82,472	68.50	56,494

Table 4.—Summary of beehive-coke operations in the United States in 1976, by State

State	Plants in existence Dec. 31	Coal carbon-ized (thousand short tons)	Yield of coke from coal (percent)	Coke produced (thousand short tons)
Pennsylvania, Virginia, West Virginia:				
Total in 1976	3	941	64.29	605
Total in 1975	4	1,128	63.21	713

Table 5.—Production of oven and beehive coke in the United States, by month

(Thousand short tons)

Month	1975 Total[1]	1975 Daily average[2]	1976 Total[1]	1976 Daily average[2]
Oven coke:				
January	4,924	159	4,551	147
February	4,750	170	4,372	151
March	5,324	172	5,041	163
April	5,030	168	4,884	163
May	5,052	163	5,069	164
June	4,765	159	4,938	165
July	4,532	146	5,007	162
August	4,427	143	4,785	154
September	4,250	142	4,720	157
October	4,527	146	4,857	157
November	4,365	146	4,752	158
December	4,549	147	4,751	153
Total[1]	56,494	155	57,728	158
Beehive coke:				
January	70	2	49	2
February	68	2	49	2
March	67	2	54	2
April	62	2	55	2
May	56	2	55	2
June	52	2	55	2
July	59	2	51	2
August	60	2	48	2
September	62	2	50	2
October	60	2	42	1
November	57	2	42	1
December	40	1	55	2
Total[1]	713	2	605	2
Total:				
January	4,994	161	4,601	148
February	4,818	172	4,421	152
March	5,391	174	5,096	164
April	5,092	170	4,939	165
May	5,108	165	5,124	165
June	4,817	161	4,993	166
July	4,591	148	5,058	163
August	4,487	145	4,833	156
September	4,312	144	4,770	159
October	4,586	148	4,899	158
November	4,422	147	4,795	160
December	4,589	148	4,805	155
Total[1]	57,207	157	58,333	160

[1]Data may not add to totals shown because of independent rounding.
[2]Daily average calculated by dividing monthly production by number of days in month.

Table 6.—Production of oven coke in the United States, by type of plant

(Thousand short tons)

Month	1975		1976	
	Merchant plants	Furnace plants	Merchant plants	Furnace plants
Production:				
January	390	4,534	375	4,176
February	372	4,378	364	4,008
March	429	4,895	399	4,642
April	399	4,631	368	4,516
May	406	4,646	371	4,698
June	380	4,385	361	4,577
July	377	4,154	355	4,653
August	388	4,039	361	4,424
September	384	3,866	357	4,363
October	409	4,118	354	4,503
November	392	3,973	348	4,404
December	389	4,160	351	4,400
Total[1]	4,716	51,778	4,363	53,365
Daily average:				
January	13	146	12	135
February	13	156	13	138
March	14	158	13	150
April	13	154	12	151
May	13	150	12	154
June	13	146	12	153
July	12	134	11	150
August	13	130	12	143
September	13	129	12	145
October	13	133	11	145
November	13	132	12	147
December	13	134	11	142
Average for year	13	142	12	146

[1]Data may not add to totals shown because of independent rounding.

Table 7.—Production of oven coke and number of plants in the United States by type of plant

Year	Number of active plants[1]		Coke produced (thousand short tons)		Percent of production	
	Merchant plants	Furnace plants	Merchant plants	Furnace plants	Merchant plants	Furnace plants
1972	14	[2]49	5,626	54,228	9.4	90.6
1973	14	[2]49	5,271	58,225	8.3	91.7
1974	14	48	5,106	55,630	8.4	91.6
1975	14	48	4,716	51,778	8.3	91.7
1976	13	48	4,363	53,365	7.6	92.4

[1]Includes plants operating any part of the year.
[2]Includes one tar-refining plant.

Table 8.—Production of coke in the United States, by State

(Thousand short tons)

State	1975	1976
Oven coke:		
Alabama	4,690	4,662
California, Colorado, Utah	2,996	3,241
Illinois	1,924	1,706
Indiana	9,246	8,259
Kentucky, Missouri, Tennessee, Texas	1,748	1,336
Maryland and New York	5,298	6,341
Michigan	3,243	3,393
Minnesota and Wisconsin	780	716
Ohio	8,467	8,430
Pennsylvania	15,395	16,175
West Virginia	2,708	3,469
Total	[1]56,494	57,728
Beehive coke:		
Pennsylvania	713	605
Virginia	([2])	([2])
West Virginia	([2])	([2])
Total	713	605
Grand total	57,207	58,333

[1]Data do not add to total shown because of independent rounding.
[2]Included with Pennsylvania to avoid disclosing individual company confidential data.

Table 9.—Breeze recovered at coke plants in the United States in 1976, by State

(Thousand short tons and thousand dollars)

State	Yield per ton of coal[1] (percent)	Produced (quantity)	Used by producers: In steam plants, Quantity	Used by producers: In steam plants, Value	Used by producers: In agglomerating plants, Quantity	Used by producers: In agglomerating plants, Value	Used by producers: For other industrial use, Quantity	Used by producers: For other industrial use, Value	Sold: Quantity	Sold: Value	Stocks in hand Dec. 31
Oven coke:											
Alabama	4.00	262	--	--	(2)	(2)	21	795	154	5,216	50
California, Colorado, Utah	4.27	218	(2)	(2)	150	4,536	19	476	58	2,357	37
Illinois	9.74	270	(2)	(2)	(2)	(2)	20	271	101	2,260	70
Indiana	8.82	1,082	--	--	424	15,651	410	15,479	429	16,305	306
Kentucky, Missouri, Tennessee, Texas	6.06	116	(2)	(2)	--	--	61	2,069	39	1,338	35
Maryland and New York	4.89	438	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	135
Michigan	4.22	202	(2)	(2)	--	--	(2)	(2)	162	4,991	37
Minnesota, Wisconsin, West Virginia	6.05	374	(2)	(2)	(2)	(2)	57	1,128	161	5,088	86
Ohio	5.69	694	(2)	(2)	(2)	(2)	93	2,933	518	15,967	97
Pennsylvania	2.99	687	(2)	(2)	302	11,358	86	2,236	224	6,590	277
Undistributed	--	--	197	4,532	486	9,336	69	2,268	--	--	--
Total 1976[3]	5.12	4,342	197	4,532	1,363	40,380	838	27,655	1,846	60,112	1,134
Merchant plants	6.21	365	129	3,338	--	--	133	2,130	121	5,314	202
Furnace plants	5.11	3,978	68	1,194	1,363	40,880	705	25,525	1,725	54,798	931
Total 1975	5.21	4,281	257	4,413	1,202	36,900	715	20,615	1,953	62,897	1,035

[1]Calculated by dividing production by coal carbonized at plants actually recovering breeze.
[2]Included with "Undistributed" to avoid disclosing individual company confidential data.
[3]Data may not add to totals shown because of independent rounding.

Table 10.—Oven- and beehive-coke breeze used and sold in the United States, by use

(Thousand short tons)

Year	Used by producers: In steam plants	Used by producers: In agglomerating plants	Used by producers: For other industrial use	Sold	Average value per ton
1972	265	1,305	704	[1]2,113	$10.59
1973	234	1,689	917	[1]2,165	10.39
1974	204	1,470	971	2,310	17.83
1975	257	1,202	715	1,953	32.21
1976	197	1,363	838	1,846	32.56

[1]Does not include beehive-coke breeze sold (to avoid disclosing individual company confidential data).

Table 11.—Apparent consumption of coke in the United States

(Thousand short tons)

Year	Total production	Imports	Exports	Net change in stocks	Apparent consumption[1]	Consumption: In iron furnaces[2]: Quantity	Consumption: In iron furnaces[2]: Percent	Consumption: All other purposes: Quantity	Consumption: All other purposes: Percent
1972	60,507	185	1,232	-586	60,046	54,607	90.9	5,439	9.1
1973	64,325	1,078	1,395	-1,757	65,765	60,720	92.3	5,045	7.7
1974	61,581	3,540	1,278	-249	64,092	58,441	91.2	5,651	8.8
1975	57,207	1,819	1,273	+4,066	53,687	48,817	90.9	4,870	9.1
1976	58,333	1,311	1,315	+1,495	56,834	51,561	90.7	5,273	9.3

[1]Production plus imports, minus exports, plus or minus net change in stocks.
[2]American Iron and Steel Institute; figures include coke consumed in manufacturing ferroalloys.

Table 12.—Coke and coking coal consumed per short ton of pig iron and ferroalloys produced in the United States

Year	Coke per short ton of pig iron and ferroalloys[1] (pounds)	Yield coke from coal (percent)	Coking coal per short ton of pig iron and ferroalloys (pounds, calculated)
1972	1,221.6	69.0	1,767.9
1973	1,200.0	68.4	1,754.4
1974	1,218.7	68.4	1,782.8
1975	1,221.6	68.4	1,786.0
1976	1,187.0	68.9	1,722.8

[1]American Iron and Steel Institute; consumption of pig iron only, excluding furnace making ferroalloys, was 1,216.2, 1972; 1,193.8, 1973; and not available in 1974, 1975, and 1976.

Table 13.—Oven coke produced in the United States, used by producers, and sold in 1976, by State

(Thousand short tons and thousand dollars)

State	Produced (quantity)	Used by producing companies: In blast furnaces		Used by producing companies: For other purposes[1]		Commercial sales: To blast furnace plants	
		Quantity	Value	Quantity	Value	Quantity	Value
Alabama	4,662	2,522	198,436	37	3,279	829	66,665
California, Colorado, Utah	3,241	2,801	216,789	12	1,102	--	--
Illinois	1,706	1,751	138,657	[2]	[2]	[3]	[3]
Indiana	8,259	7,701	621,675	9	757	82	5,398
Kentucky, Missouri, Tennessee, Texas	1,336	[3]	[3]	59	6,001	[3]	[3]
Maryland and New York	6,341	5,693	558,078	81	8,876	[3]	[3]
Michigan	3,393	[3]	[3]	[4]	[4]	[3]	[3]
Minnesota, West Virginia, Wisconsin	4,185	3,619	328,080	[4]	[4]	[3]	[3]
Ohio	8,430	7,324	587,192	53	5,097	561	43,039
Pennsylvania	16,175	14,385	1,251,191	241	20,810	354	31,499
Undistributed	--	3,350	279,564	--	--	975	74,222
Total 1976[5]	57,728	49,147	4,179,662	493	45,923	2,801	220,823
At merchant plants	4,363	49,147	4,179,662	149	15,776	1,215	95,249
At furnace plants	53,365	--	--	344	30,147	1,586	125,574
Total 1975	56,494	46,233	3,885,045	411	43,311	2,682	197,572

State	Commercial sales—Continued: To foundries		To other industrial plants[6]		Total[5]	
	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	823	92,811	[3]	[3]	[3]	[3]
California, Colorado, Utah	[3]	[3]	[3]	[3]	95	7,978
Illinois	--	--	--	--	[3]	[3]
Indiana	[3]	[3]	[3]	[3]	590	61,703
Kentucky, Missouri, Tennessee, Texas	[3]	[3]	[3]	[3]	977	85,809
Maryland and New York	[3]	[3]	[3]	[3]	260	25,035
Michigan	[3]	[3]	[3]	[3]	230	23,637
Minnesota, West Virginia, Wisconsin	[3]	[3]	156	11,502	676	63,513
Ohio	287	33,234	54	3,806	901	80,079
Pennsylvania	382	43,703	260	20,635	996	95,836
Undistributed	1,349	155,282	440	36,369	1,826	174,572
Total 1976[5]	2,840	325,030	910	72,311	6,552	618,163
At merchant plants	2,445	280,088	522	44,320	4,182	419,657
At furnace plants	396	44,941	388	27,991	2,370	198,507
Total 1975	2,392	254,789	722	55,611	5,796	507,972

[1]Comprises 167,000 tons valued at $18,417,000 used in foundries; 326,000 tons valued at $27,506,000 for other purposes.
[2]Included with Indiana to avoid disclosing individual company confidential data.
[3]Included with "Undistributed" to avoid disclosing individual company confidential data.
[4]Included with Ohio to avoid disclosing individual company confidential data.
[5]Data may not add to totals shown because of independent rounding.
[6]Includes coke used "For residential heating."

Table 14.—Production and sales of beehive coke in the United States

(Thousand short tons and thousand dollars)

State	Produced (quantity)	Commercial sales: To blast-furnace plants		Commercial sales: To other industrial plants		Commercial sales: Total	
		Quantity	Value	Quantity	Value	Quantity	Value
Pennsylvania, Virginia, and West Virginia:							
1976	605	607	43,996	(1)	(1)	607	43,996
1975	713	708	45,959	(1)	(1)	708	45,959

[1]Included with beehive coke sold "to blast furnace plants" to avoid disclosing individual company confidential data.

Table 15.—Distribution of oven and beehive coke and breeze in 1976[1]

(Thousand short tons)

Consuming State	Coke: To blast-furnace plants	Coke: To foundries	Coke: For residential heating	Coke: To other industrial plants[2]	Coke: Total[3]	Breeze
Alabama	2,640	325	2	74	3,039	175
Arizona	--	--	--	3	3	--
Arkansas	--	--	--	--	--	(4)
California	1,108	37	--	48	1,193	65
Colorado	763	7	--	20	789	76
Connecticut	--	7	--	--	7	(4)
Delaware	--	--	--	--	--	(4)
Florida	--	2	--	6	8	33
Georgia	--	8	--	5	13	1
Idaho	--	(4)	--	75	75	--
Illinois	3,356	174	--	7	3,537	319
Indiana	9,409	143	(4)	98	9,651	1,070
Iowa	--	73	--	--	73	--
Kansas	--	7	--	--	7	--
Kentucky	660	40	--	32	732	72
Louisiana	--	1	--	5	6	(4)
Maine	--	1	--	1	2	--
Maryland	2,572	5	--	2	2,579	222
Massachusetts	--	12	--	--	12	--
Michigan	4,344	757	--	23	5,124	221
Minnesota	1	15	--	25	41	21
Mississippi	--	(4)	--	1	2	1
Missouri	--	15	--	84	98	22
Montana	--	--	--	21	21	16
Nebraska	--	3	--	(4)	4	--
New Jersey	--	42	--	29	71	15
New York	2,945	138	--	31	3,114	265
North Carolina	--	7	--	2	9	2
North Dakota	--	1	--	13	14	--
Ohio	8,665	410	--	76	9,151	500
Oklahoma	--	1	--	--	1	--
Oregon	--	6	--	10	16	--
Pennsylvania	11,424	220	(4)	376	12,021	662
Rhode Island	--	3	--	--	3	--
South Carolina	--	7	--	28	34	5
South Dakota	--	(4)	--	--	(4)	--
Tennessee	67	73	--	41	181	86
Texas	530	82	--	44	656	52
Utah	930	10	--	15	956	67
Virginia	--	77	--	1	78	36
Washington	--	2	--	1	3	--
West Virginia	3,098	3	--	12	3,113	154
Wisconsin	--	127	(4)	1	129	24
Wyoming	--	(4)	--	4	4	--
Total[3]	52,513	2,842	2	1,213	56,568	4,184
Exported	36	166	--	28	230	61
Grand total[3]	52,549	3,007	2	1,242	56,798	4,245

[1]Based on reports from producers showing destination and principle end-use of coke used and sold. Does not include imported coke which totaled 1,311,000 tons in 1976.
[2]Includes coke used "For residential heating."
[3]Data may not add to totals shown because of independent rounding.
[4]Less than 500 short tons.

Table 16.—Producers' stocks of coke and breeze in the United States on December 31, 1976, by State

(Thousand short tons)

State	Coke				Breeze
	Blast furnace	Foundry	Residential heating and other	Total[1]	
Oven coke					
Alabama	719	32	1	752	50
California, Colorado, Utah	610	--	--	610	37
Illinois	235	--	--	235	70
Indiana	506	6	1	512	306
Kentucky, Missouri, Tennessee, Texas	10	10	17	37	35
Maryland and New York	562	28	28	618	135
Michigan	158	4	2	165	37
Minnesota and Wisconsin	152	29	2	184	34
Ohio	782	3	20	806	97
Pennsylvania	2,390	65	70	2,524	277
West Virginia	46	--	--	46	52
Total 1976[1]	6,168	177	141	6,487	1,134
At merchant plants	76	116	122	314	203
At furnace plants	6,092	61	20	6,173	931
Total 1975	4,729	188	78	4,996	1,035
Beehive coke:					
Pennyslvania:					
1976	4	--	--	4	--
1975	5	--	--	5	--

[1]Data may not add to totals shown because of independent rounding.

Table 17.—Producers' month-end stocks of oven coke in the United States

(Thousand short tons)

Month	At merchant plants		At furnace plants		Total[1]	
	1975	1976	1975	1976	1975	1976
January	29	272	1,025	4,820	1,054	5,092
February	43	257	1,219	4,737	1,262	4,994
March	70	258	1,372	4,847	1,442	5,105
April	99	254	1,634	4,808	1,733	5,062
May	131	256	2,131	4,736	2,261	4,992
June	148	225	2,741	4,504	2,889	4,729
July	199	258	3,323	4,383	3,522	4,641
August	213	244	3,654	4,202	3,867	4,445
September	203	239	3,618	4,511	3,821	4,750
October	209	241	3,899	4,938	4,108	5,179
November	231	261	4,291	5,539	4,522	5,800
December	278	314	4,718	6,173	4,996	6,487

[1]Data may not add to totals shown because of independent rounding.

Table 18.—Average receipts per short ton of coke sold (commercial sales) in the United States, by use

Year	To blast furnace plants	To foundries	To other industrial plants	For residential heating	Total
Oven coke:					
1972	$30.64	$51.16	$36.43	(1)	$40.70
1973	32.41	54.73	36.55	(1)	42.92
1974	53.28	78.92	59.33	(1)	65.74
1975	73.67	106.52	77.02	(1)	87.64
1976	78.84	114.45	79.46	(1)	94.35
Beehive coke:					
1972	22.01	--	W	--	W
1973	27.31	--	W	--	W
1974	44.02	--	--	--	44.02
1975	65.17	--	(2)	--	65.17
1976	72.48	--	(2)	--	72.48

W Withheld to avoid disclosing individual company confidential data.
[1]Included with "To other industrial plants" to avoid disclosing individual company confidential data.
[2]Included with "To blast furnace plants" to avoid disclosing individual company confidential data.

Table 19.—Coke exported from the United States, by country and customs district

	1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
COUNTRY						
Algeria	--	--	58	$59	--	--
Australia	101	$26	--	--	--	--
Belgium-Luxembourg	52,723	1,507	86,548	3,620	53,527	$1,843
Brazil	7,059	846	12,500	1,778	30,605	758
Canada	709,717	24,760	680,595	38,431	754,433	36,763
Dominican Republic	791	23	10	2	10	2
France	127	64	17,437	737	22	26
Germany, West	119,331	2,533	116,979	3,877	78,438	2,443
Iran	2,879	91	85	40	41	7
Iraq	--	--	1,894	900	1,653	278
Italy	6,405	184	235	6	264	6
Japan	4,539	304	1,058	1,054	64,726	4,071
Mexico	157,956	6,107	107,288	9,780	87,684	9,287
Netherlands	95,935	2,389	172,929	8,103	172,503	7,449
Norway	12,628	389	124	58	67	25
Panama	137	20	--	--	--	--
Peru	128	5	1,131	158	24,414	1,040
Singapore	1,760	155	126	61	65	36
South Africa, Republic of	586	156	--	--	--	--
Spain	92,864	3,487	20,522	924	25,937	965
Sweden	4,592	111	--	--	--	--
Taiwan	95	11	110	49	5	1
Turkey	--	--	1,801	859	--	--
United Kingdom	732	110	616	62	120	17
Venezuela	1,812	64	49,815	3,983	18,810	1,303
Yugoslavia	3,466	132	--	--	--	--
Other	1,318	90	1,045	191	1,401	406
Total	1,277,681	43,564	1,272,906	74,732	1,314,725	66,726
CUSTOMS DISTRICT						
Baltimore	30,777	801	90	17	172	29
Buffalo	366,858	13,223	233,939	17,304	239,010	17,830
Charleston, S.C	551	59	189	89	45	38
Chicago	71,902	2,033	57,323	1,823	96,379	2,518
Cleveland	12,040	146	9,500	285	110,019	3,333
Detroit	304,224	9,770	392,711	18,159	321,117	11,534
Duluth	11,851	255	15,217	440	46,670	1,135
El Paso	637	25	696	80	868	108
Great Falls	3,751	165	382	45	8,865	553
Houston	5,645	390	745	295	1,030	436
Laredo	154,657	5,982	105,853	9,619	86,111	9,099
Los Angeles	66,997	1,218	37,934	2,094	350	248
Miami	322	28	70	10	39	6
Mobile	1,086	48	53,141	4,448	28,396	512
New Orleans	17,119	1,075	26,054	2,985	19,571	1,148
New York City	5,046	121	970	56	1,726	125
Nogales	551	23	123	16	74	11
Norfolk	114,803	3,057	170,302	7,017	101,629	3,875
Ogdensburg	4,997	116	4,427	144	2,997	96
Pembina	24,988	1,065	12,860	1,365	20,440	1,695
Philadelphia	68,382	3,452	146,590	7,992	225,163	10,405
San Diego	2,111	77	616	65	640	53
San Francisco	--	--	19	3	1,170	1,665
Seattle	8,249	432	3,113	356	2,244	274
Other	137	3	42	25	--	--
Total	1,277,681	43,564	1,272,906	74,732	1,314,725	66,726

Table 20.—U.S. imports for consumption of coke, by country and customs district

	1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
COUNTRY						
Argentina	--	--	--	--	21,341	$796
Belgium-Luxembourg	661	$57	3,504	$369	112,136	5,172
Canada	194,731	7,932	148,386	10,366	133,519	9,893
France	2,222	127	--	--	113,432	9,315
Germany, West	2,761,585	156,005	1,387,755	123,114	891,105	83,419
Italy	7,953	572	42,890	5,005	--	--
Japan	4	(1)	9,071	722	11,023	557
Netherlands	62,917	5,883	99,706	10,110	17,151	1,448
New Zealand	8,342	613	--	--	--	--
Norway	55,516	3,860	--	--	--	--
South Africa, Republic of	34,222	937	59,319	2,374	11,765	466
Sweden	--	--	3,708	384	--	--
U.S.S.R	28,733	2,379	16,177	1,424	--	--
United Kingdom	383,440	14,800	48,465	2,620	--	--
Total	3,540,326	193,165	1,818,981	156,488	1,311,472	111,066
CUSTOMS DISTRICT						
Baltimore	739,434	35,203	348,267	29,128	--	--
Buffalo	13,098	696	48,312	2,259	138,496	12,062
Charleston, S.C	11,759	323	--	--	--	--
Chicago	357,555	22,299	126,434	13,011	515,766	44,697
Cleveland	84,142	5,694	7,588	391	--	--
Detroit	329,724	25,800	382,183	30,917	395,434	38,079
Duluth	11,570	921	83	2	--	--
Great Falls	119,199	4,083	88,956	7,378	68,860	5,571
Milwaukee	6,180	808	--	--	--	--
Minneapolis	42	1	--	--	--	--
New Orleans	283,248	17,481	305,998	24,262	157,560	9,188
New York City	4	(1)	86,681	8,560	--	--
Ogdensburg	--	--	180	2	350	5
Pembina	2,040	101	--	--	--	--
Philadelphia	1,570,657	78,834	414,620	39,836	--	--
Portland, Maine	30	1	--	--	--	--
Port Arthur	--	--	--	--	21,341	796
St. Albans	805	54	19	3	60	2
Seattle	--	--	589	17	2,582	109
Tampa	8,342	613	9,071	722	11,023	557
Wilmington, N.C	2,497	253	--	--	--	--
Total	3,540,326	193,165	1,818,981	156,488	1,311,472	111,066

[1]Less than 1/2 unit.

Table 21.—Coke: World production, by type and country

(Thousand short tons)

Kind of coke and country[1]	1974	1975	1976^{p}
METALLURGICAL COKE[2]			
North America:			
Canada[3] [4]	6,008	5,819	5,830
Mexico	^{r}2,261	2,282	2,395
United States	61,581	57,207	58,333
South America:			
Argentina	^{r}728	^{e}750	^{e}750
Brazil	2,056	2,494	^{e}2,540
Chile	334	233	236
Colombia	^{r}441	441	^{e}440
Peru^{e}	^{r}40	^{r}40	40
Europe:			
Austria[3]	1,911	1,771	1,779
Belgium	8,874	6,314	8,599
Bulgaria	1,442	1,504	^{e}1,540
Czechoslovakia	10,258	10,179	11,884
France[3]	12,874	12,114	11,970
Germany, East	2,016	1,961	1,866
Germany, West	38,494	38,379	35,220
Greece	410	464	370
Hungary	^{r}847	850	853
Italy	9,442	8,945	8,785
Netherlands[3]	2,959	2,954	3,101

See footnotes at end of table.

Table 21.—Coke: World production, by type and country —Continued

(Thousand short tons)

Kind of coke and country[1]	1974	1975	1976[p]
METALLURGICAL COKE[2] —Continued			
Europe —Continued			
Norway	345	292	316
Poland[5]	r18,663	19,021	19,770
Portugal	178	197	e200
Romania	r2,040	2,510	e2,800
Spain[6]	4,677	5,266	4,874
Sweden[3 4]	530	904	1,182
U.S.S.R.[3]	91,096	92,090	e93,000
United Kingdom	r17,388	17,484	17,366
Yugoslavia	1,372	1,392	1,969
Africa:			
Egypt[e]	400	400	440
Rhodesia, Southern[e]	270	270	275
South Africa, Republic of	r e4,000	4,898	5,079
Asia:			
China, People's Republic of[e]	30,900	30,900	30,900
India[7]	9,038	9,751	e9,900
Iran[e]	550	550	550
Japan	50,301	49,382	47,891
Korea, North[e]	2,400	2,400	2,500
Korea, Republic of	661	676	1,216
Taiwan	206	222	251
Turkey	r1,368	1,389	e1,850
Oceania: Australia	5,637	5,775	5,853
Total metallurgical coke	r404,996	400,470	404,713
GASHOUSE COKE[8]			
South America:			
Brazil[e]	41	41	44
Chile	--	5	6
Uruguay	15	15	13
Europe:			
Denmark	79	91	e91
France	665	502	499
Germany, West	1,702	1,378	1,070
Greece	13	13	e13
Hungary	r301	302	e303
Ireland	r37	37	e37
Poland	r1,240	1,109	e1,100
Switzerland	44	--	--
United Kingdom	r18	e1	e1
Africa:			
Egypt[e]	33	33	33
South Africa, Republic of[e]	110	110	110
Asia:			
India	50	55	e55
Japan	4,838	4,650	4,372
Taiwan	(9)	--	--
Turkey	173	e160	e165
Oceania:			
Australia	72	e66	e66
New Zealand	34	33	45
Total gashouse coke	r9,465	8,601	8,023

See footnotes at end of table.

Table 21.—Coke: World production, by type and country —Continued

(Thousand short tons)

Kind of coke and country[1]	1974	1975	1976[p]
ALL OTHER TYPES[10]			
Europe: Germany, East[11]	6,467	6,115	[e]6,100
Asia: India[e]	4,100	4,100	4,100
Total all other types	10,567	10,215	10,200
Grand total	[r]425,028	419,286	422,936

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, Algeria, Australia, Malaysia, the People's Republic of China, Mexico, Norway, Romania, and the U.S.S.R. have produced gashouse coke in previous years and may have continued production during the time period covered by this table. However, no official statistics are available and information is inadequate to make reliable estimates of production levels. Except where otherwise noted, coke breeze has been excluded from this table.

[2]Coke produced at high temperatures in conventional carbonizing equipment (including slot and beehive coke ovens).

[3]Includes breeze.

[4]Includes relatively small amounts of gas coke.

[5]May include gas coke.

[6]Includes relatively small amounts of low-temperature coke.

[7]Data are total of so-called hard coke production from collieries and coke plants (including those at steelworks).

[8]Includes coke produced at high temperatures in carbonizing equipment designed primarily for gas manufacture (horizontal and vertical coal-gas retorts). In addition to the countries listed, Canada and Finland produce gas coke. However, this figure is not reported separately and has been included with metallurgical coke.

[9]Less than 1/2 unit.

[10]Includes coke produced at low and medium temperatures, as well as that produced in unconventional equipment (chain-grate cokers). In addition to the countries listed, the U.S.S.R. may produce coke from brown coal, but output is not officially reported and no basis is available for reliably estimating output levels.

[11]Includes coke produced from lignite at high temperature.

Table 22.—Quantity, sulfur content, and value at ovens of coal carbonized in the United States in 1976, by State

State	Coal carbonized: Thousand short tons	Coal carbonized: Average sulfur content (percent)	Coal carbonized: Value: Total (thousands)	Coal carbonized: Value: Average per ton	Coal per ton of coke: Short tons	Coal per ton of coke: Value
Oven coke:						
Alabama	6,588	0.9	$263,865	$40.05	1.41	$56.47
California, Colorado, Utah	5,085	.7	206,178	40.55	1.57	63.66
Illinois	2,771	.9	106,625	38.48	1.62	62.34
Indiana	12,267	.8	498,502	40.64	1.49	60.55
Kentucky, Missouri, Tennessee, Texas	1,913	.6	85,461	44.67	1.43	63.88
Maryland and New York	8,952	.9	507,202	56.65	1.41	79.88
Michigan	4,782	.7	255,668	53.46	1.41	75.38
Minnesota and Wisconsin	986	1.0	48,014	48.70	1.38	67.21
Ohio	12,192	.8	498,613	40.90	1.45	59.31
Pennsylvania	23,033	1.1	1,000,770	43.45	1.42	61.70
West Virginia	5,195	1.1	228,202	43.93	1.50	65.90
Total 1976[1]	83,764	.9	3,699,102	44.16	1.45	64.03
At merchant plants	5,874	.7	320,029	54.48	1.35	73.55
At furnace plants	77,890	.9	3,379,072	43.38	1.46	63.34
Total 1975	82,472	.9	3,645,697	44.21	1.46	64.55
Beehive coke: Pennsylvania, Virginia, West Virginia:						
1976	941	--	W	W	1.57	W
1975	1,128	--	W	W	1.58	W

W Withheld to avoid disclosing individual company confidential data.
[1]Data may not add to totals shown because of independent rounding.

Table 23.—Bituminous coal carbonized in coke ovens in the United States, by month

(Thousand short tons)

Month	1975: Slot	1975: Beehive	1975: Total[1]	1976: Slot	1976: Beehive	1976: Total[1]
January	7,191	112	7,303	6,655	77	6,732
February	6,923	108	7,032	6,528	77	6,605
March	7,772	108	7,880	7,176	86	7,262
April	7,327	100	7,427	6,992	85	7,077
May	7,193	89	7,283	7,311	85	7,396
June	6,919	81	7,000	7,069	85	7,154
July	6,547	91	6,639	7,188	79	7,267
August	6,470	94	6,564	6,965	74	7,039
September	6,190	97	6,287	6,831	77	6,908
October	6,565	94	6,659	6,977	65	7,042
November	6,396	89	6,485	6,835	66	6,901
December	6,654	62	6,716	6,856	85	6,941
Total[1]	82,147	1,128	83,274	83,383	941	84,325

[1]Data may not add to totals shown because of independent rounding.

Table 24.—Anthracite carbonized at oven-coke plants in the United States, by month

(Thousand short tons)

Month	1975	1976
January	30	28
February	29	28
March	33	34
April	27	35
May	25	31
June	22	32
July	26	33
August	26	31
September	26	32
October	29	30
November	27	33
December	28	34
Total[1]	326	380

[1]Data may not add to totals shown because of independent rounding.

Table 25.—Average value per short ton of coal carbonized at oven-coke plants in the United States, by State

State	1975	1976
Alabama	$40.27	$40.05
California, Colorado, Utah	37.11	40.55
Illinois	39.80	38.48
Indiana	47.25	40.64
Kentucky, Missouri, Tennessee, Texas	42.87	44.67
Maryland and New York	57.27	56.65
Michigan	55.43	53.46
Minnesota and Wisconsin	48.37	48.70
Ohio	42.12	40.90
Pennsylvania	40.69	43.45
West Virginia	40.59	43.93
Average	44.21	44.16
Value of coal per ton of coke	64.55	64.03

Table 26.—Average volatile content of bituminous coal carbonized by oven-coke plants in the United States

(Thousand short tons)

Year	High		Medium		Low		Total	
	Quantity	Volatile content (percent)	Quantity	Volatile content (percent)	Quantity	Volatile content (percent)	Quantity	Volatile content (percent)
1972	60,536	34.7	8,754	26.4	16,923	16.8	86,213	30.3
1973	64,486	34.6	10,090	26.6	17,762	16.2	92,338	30.2
1974	61,344	34.8	10,763	25.6	16,303	17.9	88,410	30.6
1975	57,488	34.8	9,619	25.7	15,040	18.3	82,147	30.7
1976	56,847	34.9	9,982	26.4	16,554	17.4	83,383	30.4

Table 27.—Coal received by oven-coke plants in the United States in 1976, by consuming State and volatile content[1]

(Thousand short tons)

Consuming State	High volatile		Medium volatile		Low volatile		Total coal receipts[2]
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	
Alabama	1,830	28.0	3,906	59.9	787	12.1	6,524
California, Colorado, Utah	3,803	75.6	1,101	21.9	128	2.5	5,032
Illinois	2,145	78.8	194	7.1	383	14.1	2,722
Indiana	7,522	59.3	1,977	15.6	3,183	25.1	12,682
Kentucky, Missouri, Tennessee, Texas	1,091	62.0	71	4.0	599	34.0	1,761
Maryland and New York	5,928	63.2	1,011	10.8	2,437	26.0	9,377
Michigan	2,599	56.4	568	12.3	1,442	31.3	4,609
Minnesota and Wisconsin	353	39.6	198	22.2	340	38.2	891
Ohio	9,674	75.5	571	4.5	2,566	20.0	12,812
Pennsylvania	16,979	73.2	1,452	6.3	4,769	20.5	23,200
West Virginia	4,154	78.5	31	.6	1,105	20.9	5,290
Total 1976[2]	56,080	66.0	11,080	13.1	17,739	20.9	84,899
At merchant plants	2,392	40.5	837	14.2	2,670	45.3	5,898
At furnace plants	53,688	67.9	10,243	13.0	15,070	19.1	79,000
Total 1975	56,437	66.5	10,939	12.9	17,509	20.6	84,886

[1]Volatile matter on moisture-free basis: High volatile—over 31%; medium volatile; 22% to 31%; and low volatile; 14% to 22%.
[2]Data may not add to totals shown because of independent rounding.

Table 28.—Origin of coal received by oven-coke plants in the United States in 1976, by producing county and volatile content[1]

(Thousand short tons)

Source of coal	Volatile content			Total[2]
	High	Medium	Low	
Alabama:				
Bibb	168	--	--	168
Blount	26	110	--	136
Cullman	491	40	--	531
De Kalb	1	--	53	53
Etowah	31	8	--	40
Jefferson	413	3,779	--	4,191
Tuscaloosa	--	66	--	66
Walker	183	--	--	183
Arkansas:				
Johnson	--	--	128	128
Sebastian	--	--	61	61
Colorado:				
Gunnison	884	--	--	884
Las Animas	619	--	--	619
Pitkin	--	953	--	953
Illinois:				
Franklin	1,375	--	--	1,375
Jefferson	2,052	--	--	2,052
Saline	128	--	--	128
Kentucky:				
Clay	68	--	--	68
Floyd	1,427	--	--	1,427
Greenup	123	--	--	123
Harlan	2,563	--	--	2,563
Knox	220	--	--	220
Leslie	11	--	--	11
Letcher	2,546	--	--	2,546
Perry	65	--	--	65
Pike	4,426	--	--	4,426
Whitley	230	--	--	230
Maryland: Garrett	--	11	--	11
New Mexico: Colfax	826	--	--	826
Oklahoma:				
Haskell	--	198	--	198
Le Flore	--	--	78	78
Pittsburg	15	--	--	15
Rogers	149	--	--	149
Pennsylvania:				
Anthracite	--	--	377	377
Bituminous:				
Allegheny	1,412	--	--	1,412
Armstrong	686	--	--	686
Butler	235	--	--	235
Cambria	--	1,662	2,422	4,085
Centre	--	38	--	38
Clearfield	--	98	358	456
Fayette	235	--	--	235
Greene	5,625	--	--	5,625
Indiana	3	--	--	3
Jefferson	3	--	--	3
Lycoming	--	--	37	37
Mercer	79	--	--	79
Somerset	--	--	1,401	1,401
Washington	10,137	--	--	10,137
Westmoreland	1,242	91	--	1,333
Tennessee: Morgan	--	33	--	33
Utah: Carbon	1,573	--	--	1,573
Virginia:				
Buchanan	424	681	2,774	3,879
Dickenson	422	--	--	422
Russell	--	2	--	2
Tazewell	--	75	--	75
Wise	820	--	--	820
West Virginia:				
Barbour	21	--	--	21
Boone	2,256	--	--	2,256
Fayette	1,789	3	451	2,242
Grant	--	2	--	2
Greenbrier	--	219	--	219
Kanawha	2,394	--	--	2,394
Logan	4,668	89	--	4,757
McDowell	--	1,257	4,752	6,009
Marion	769	--	--	769
Mercer	--	--	510	510
Mingo	1,344	--	--	1,344
Nicholas	545	1,127	--	1,672

See footnotes at end of table.

Table 28.—Origin of coal received by oven-coke plants in the United States in 1976, by producing county and volatile content[1] —Continued

(Thousand short tons)

Source of coal	Volatile content			Total[2]
	High	Medium	Low	
West Virginia —Continued				
Preston	--	249	--	249
Raleigh	--	25	1,940	1,965
Randolph	12	--	--	12
Tucker	--	60	--	60
Wayne	78	--	--	78
Wyoming	268	203	2,397	2,868
Total[2]	56,080	11,080	17,739	84,899

[1]Volatile matter on moisture-free basis; high volatile, over 31%; medium volatile, 22% to 31%; and low volatile, 14% to 22%.

[2]Data may not add to totals shown because of independent rounding.

Table 29.—Origin of coal received by oven-coke plants in 1976, by State

(Thousand short tons)

Consuming State	Producing State: Alabama	Arkansas	Colorado	Illinois	Kentucky	Maryland	New Mexico	Ohio	Oklahoma
Alabama	5,124	--	--	--	523	--	--	--	--
California, Colorado, Utah	--	128	2,456	--	--	--	806	--	148
Illinois	--	--	--	982	960	--	--	--	--
Indiana	179	12	--	2,530	2,778	--	20	--	13
Kentucky, Missouri, Tennessee, Texas	53	--	--	--	--	--	--	--	266
Maryland and New York	--	--	--	--	2,002	--	--	--	--
Michigan	--	--	--	--	1,326	--	--	--	4
Minnesota and Wisconsin	--	--	--	--	83	--	--	--	9
Ohio	12	--	--	44	1,662	11	--	--	--
Pennsylvania	--	--	--	--	1,908	--	--	--	--
West Virginia	--	49	--	--	437	--	--	--	--
Total 1976[1]	5,368	189	2,456	3,556	11,679	11	826	--	441
At merchant plants	598	--	--	--	100	--	--	--	9
At furnace plants	4,771	189	2,456	3,556	11,579	11	826	--	431
Total 1975	5,906	214	2,582	3,605	12,159	--	742	12	669

Consuming State	Producing State—Continued: Pennsylvania	Tennessee	Utah	Virginia	West Virginia	Canada	West Germany	Total[1]
Alabama	108	33	--	344	391	--	--	6,524
California, Colorado, Utah	--	--	1,494	--	--	--	--	5,032
Illinois	20	--	--	122	638	--	--	2,722
Indiana	1,783	--	--	1,054	4,312	--	--	12,682
Kentucky, Missouri, Tennessee, Texas	48	--	--	126	1,268	--	--	1,761
Maryland and New York	3,390	--	--	760	3,225	--	--	9,377
Michigan	151	--	75	190	2,862	--	--	4,609
Minnesota and Wisconsin	96	--	4	196	503	--	--	891
Ohio	4,304	--	--	1,632	5,147	--	--	12,812
Pennsylvania	13,487	--	--	657	7,148	--	--	23,200
West Virginia	2,754	--	--	117	1,933	--	--	5,290
Total 1976[1]	26,142	33	1,573	5,198	27,427	--	--	84,899
At merchant plants	280	--	4	1,174	3,733	--	--	5,898
At furnace plants	25,862	33	1,569	4,024	23,694	--	--	79,000
Total 1975	25,477	192	1,784	4,501	26,908	54	82	84,886

[1]Data may not add to totals shown because of independent rounding.

Table 30.—Quantity and percentage of captive coal received by oven-coke plants in the United States

(Thousand short tons)

Year	At merchant plants			At furnace plants			Total[1]		
	Total coal received	Captive coal		Total coal received	Captive coal		Total coal received	Captive coal	
		Quantity	Percent		Quantity	Percent		Quantity	Percent
1972	7,804	r2,325	29.8	80,158	45,354	56.7	87,962	47,679	54.2
1973	6,820	1,723	25.3	83,943	47,412	56.5	90,763	49,134	54.1
1974	6,877	1,520	22.1	81,239	44,116	54.3	88,115	45,637	51.8
1975	6,487	1,202	18.5	78,399	44,303	56.5	84,886	45,505	53.6
1976	5,898	2,291	38.8	79,000	42,840	54.2	84,899	45,132	53.2

rRevised.
[1]Data may not add to totals shown because of independent rounding.

Table 31.—Month-end stocks of bituminous coal at oven-coke plants in the United States

(Thousand short tons)

Month	1975	1976
January	7,140	8,115
February	8,010	8,514
March	8,665	9,334
April	8,980	9,931
May	9,603	10,612
June	10,009	11,257
July	8,126	8,715
August	7,340	7,258
September	7,003	8,164
October	7,729	9,037
November	8,468	9,605
December	8,671	9,804

Table 32.—Month-end stocks of anthracite coal at oven-coke plants in the United States[1]

(Thousand short tons)

Month	1975	1976
January	171	114
February	165	89
March	159	77
April	145	84
May	135	85
June	131	81
July	125	83
August	127	91
September	128	93
October	129	101
November	133	107
December	126	98

[1]Includes petrocoke.

Table 33.—Coal-chemical materials, exclusive of breeze, produced at oven-coke plants in the United States in 1976[1]

Product	Produced	Sold			Stocks, Dec. 31
			Value		
		Quantity	Total (thousands)	Average per unit	
Tar, crude ---- thousand gallons	636,382	290,536	$96,417	$0.332	44,649
Tar derivatives:					
Sodium phenolate or carbolate ---- do	2,482	2,352	351	.149	116
Crude chemical oil (tar acid oil) ---- do	5,678	5,679	2,143	.377	87
Pitch of tar:[2]					
Soft ---- thousand short tons	516	274	25,347	92.507	13
Hard ---- do	([2])	([2])	([2])	([2])	([2])
Other tar derivatives[3]	XX	XX	15,079	XX	XX
Ammonia products:					
Sulfate ---- thousand short tons	522	585	28,504	48.725	55
Liquor (NH_3 content) ---- do	5	6	562	93.667	2
Diammonium phosphate ---- do	([4])	([4])	([4])	([4])	([4])
Total ---- do	XX	XX	29,066	XX	XX
Sulfate equivalent of all forms ---- do	539	608	XX	XX	61
NH_3 equivalent of all forms ---- do	139	157	XX	XX	16
Gas:					
Used under boilers, etc ---- million cubic feet	[5]912,399	168,042	121,302	.722	--
Used in steel or allied plants ---- do		318,416	243,758	.766	--
Distributed through city mains ---- do		10,065	5,125	.509	--
Sold for industrial use ---- do		41,907	31,935	.762	--
Total[6] ---- do	[5]912,399	538,430	402,120	.747	--
Crude light oil ---- thousand gallons	[7]198,056	104,645	52,532	.502	8,831
Light oil derivatives:					
Benzene:					
Specification grades (1°, 2°, 90%) ---- do	60,411	59,822	47,526	.794	2,809
Other industrial grades ---- do	([8])	([8])	([8])	([8])	([8])
Toluene (all grades) ---- do	8,824	8,446	4,642	.550	788
Xylene (all grades) ---- do	1,496	1,251	732	.585	409
Solvent naphtha (all grades) ---- do	1,968	1,792	713	.398	223
Other light oil derivatives ---- do	3,993	1,398	505	.361	202
Total[6] ---- do	76,692	72,708	54,118	.744	4,431
Intermediate light oil ---- do	5,419	1,923	543	.282	456
Grand total[6]	XX	XX	677,716	XX	XX

XX Not applicable.
[1]Includes products of tar distillation conducted by oven-coke operators under the same corporate names.
[2]Soft-water-softening point less than 100°to 160° F, hard-over 160°F. Figures on soft pitch includes hard pitch to avoid disclosing individual company confidential data.
[3]Creosote oil, cresols, cresylic acid, naphthalene, phenol, refined tar, tar paint.
[4]Included with sulfate to avoid disclosing individual company confidential data.
[5]Includes gas used for heating ovens and gas wasted.
[6]Data may not add to totals shown because of independent rounding.
[7]Includes 89,841,000 gallons refined by coke-oven operators to make derived products shown.
[8]Included with "Specification grades" to avoid disclosing individual company confidential data.

Table 34.—Coal equivalent of the thermal materials, except coke, produced at oven-coke plants in the United States

Year	Materials produced				Estimated equivalent in heating value[1] (Billion Btu)					Coal[2] equivalent (thousand short tons)
	Coke breeze (thousand short tons)	Surplus gas (billion cubic feet)	Tar (thousand gallons)	Light oil (thousand gallons)	Coke breeze	Surplus gas	Tar	Light oil	Total	
1972	4,261	534	747,186	214,201	85,220	293,700	112,078	27,846	518,844	19,803
1973	4,902	596	732,455	226,110	98,040	327,800	109,868	29,394	565,102	21,569
1974	5,094	574	677,447	217,416	101,880	315,700	101,617	28,264	547,461	20,896
1975	4,281	527	645,537	194,814	85,620	289,850	96,831	25,326	497,627	18,993
1976	4,342	538	636,382	198,056	86,840	295,900	95,457	25,742	503,939	19,234

[1]Breeze, 10,000 Btu per pound; gas 550 Btu per cubic foot; tar, 150,000 Btu per gallon and light oil, 130,000 Btu per gallon.
[2]At 26,200 Btu per short ton of coal.

Table 35.—Average value of coal-chemical materials used or sold and of coke and breeze per short ton of coal carbonized in the United States

	1972	1973	1974	1975	1976
Ammonia products	$0.141	$0.177	$0.418	$0.397	$0.347
Light oil and its derivatives	.350	.418	1.276	1.233	1.273
Surplus gas used or sold	1.660	2.052	3.366	3.549	4.801
Tar and its derivatives (including naphthalene):					
Tar burned by producers[1]	.366	.572	.753	.945	2.890
Sold	.720	.611	1.528	1.616	1.663
Total	3.237	3.830	7.342	7.740	10.974
Coke produced[2]	22.978	26.315	50.005	57.843	59.284
Breeze produced	.533	.558	1.022	1.414	1.626
Grand total	26.748	30.703	58.369	66.997	71.884

[1]Includes pitch-of-tar.
[2]Average value of coke used or sold.

Table 36.—Percentage of coal costs recovered from the recovery of coal-chemical materials in the United States

	1972	1973	1974	1975	1976
Product:					
Ammonia products	1.0	1.0	1.2	1.0	1.0
Light oil and its derivatives	3.2	2.3	3.5	3.1	2.9
Surplus gas used or sold	10.6	11.2	9.2	8.0	10.9
Tar and its derivatives used or sold (including naphthalene)	8.0	6.5	6.3	6.2	10.3
Total	22.8	21.0	20.2	18.3	25.1
Value of coal per short ton	$15.74	$18.32	$36.49	$44.21	$44.16

Table 37.—Production and disposal of coke-oven gas in the United States in 1976, by State

(Million cubic feet)

State	Produced		Used in heating ovens	Surplus used or sold			Wasted
	Total	Thousand cubic feet per ton of coal		Quantity	Value: Thousands	Value: Average per thousand cubic feet	
Alabama	66,659	10.12	33,339	32,475	$15,975	$0.492	845
California, Colorado, Utah	65,406	12.86	20,602	44,205	34,392	.815	599
Illinois	29,204	10.54	12,170	15,455	10,388	.672	1,578
Indiana	138,429	11.29	54,414	82,513	62,585	.758	1,502
Kentucky, Missouri, Tennessee, Texas	20,137	10.53	9,247	9,567	3,689	.386	1,323
Maryland and New York	94,096	10.51	40,386	52,557	41,161	.783	1,153
Michigan	48,308	10.10	8,031	39,291	36,453	.928	986
Minnesota and Wisconsin	10,200	10.35	5,000	4,513	1,963	.435	686
Ohio	136,582	11.20	56,810	77,439	55,888	.722	2,333
Pennsylvania	243,784	10.58	106,906	135,776	105,735	.779	1,102
West Virginia	59,593	11.47	13,836	44,637	33,890	.759	1,120
Total 1976[1]	912,399	10.89	360,742	538,430	402,120	.747	13,227
At merchant plants	54,079	9.21	26,468	24,990	11,038	.442	2,621
At furnace plants	858,321	11.02	334,275	513,440	391,081	.762	10,606
Total 1975	895,279	10.86	354,569	527,238	292,694	.555	13,472

[1]Data may not add to totals shown because of independent rounding.

Table 38.—Surplus coke-oven gas used by producers in the United States and sold in 1976, by State

(Million cubic feet)

State	Used by producers					
	Under boilers, etc.			In steel or allied plants		
	Quantity	Value: Thousands	Value: Average per thousand cubic feet	Quantity	Value: Thousands	Value: Average per thousand cubic feet
Alabama	9,725	3,800	.391	19,869	11,251	.566
California, Colorado, Utah	(1)	(1)	(1)	(1)	(1)	(1)
Illinois	4,497	2,407	.535	10,249	7,552	.737
Indiana	13,554	9,865	.728	66,679	51,667	.775
Kentucky, Missouri, Tennessee, Texas	7,396	2,635	.356	(1)	(1)	(1)
Maryland and New York	7,546	5,592	.741	40,129	33,368	.832
Michigan	(1)	(1)	(1)	(1)	(1)	(1)
Minnesota and Wisconsin	3,945	1,525	.387	--	--	--
Ohio	24,073	14,783	.614	48,791	37,996	.779
Pennsylvania	41,454	34,645	.836	60,023	43,149	.719
West Virginia	22,278	16,761	.752	(1)	(1)	(1)
Undistributed	33,575	29,288	.872	72,676	58,776	.809
Total 1976[2]	168,042	121,302	.722	318,416	243,758	.766
At merchant plants	14,604	6,005	.411	(3)	(3)	(3)
At furnace plants	153,438	115,298	.751	318,416	243,758	.766
Total 1975	108,041	57,162	.529	395,733	224,454	.567

State	Sold					
	Distributed through city mains			For industrial use		
	Quantity	Value: Thousands	Value: Average per thousand cubic feet	Quantity	Value: Thousands	Value: Average per thousand cubic feet
Alabama	--	--	--	(1)	(1)	(1)
California, Colorado, Utah	--	--	--	--	--	--
Illinois	--	--	--	(1)	(1)	(1)
Indiana	(1)	(1)	(1)	--	--	--
Kentucky, Missouri, Tennessee, Texas	--	--	--	(1)	(1)	(1)
Maryland and New York	(1)	(1)	(1)	--	--	--
Michigan	--	--	--	(1)	(1)	(1)
Minnesota and Wisconsin	--	--	--	(1)	(1)	(1)
Ohio	(1)	(1)	(1)	(1)	(1)	(1)
Pennsylvania	(1)	(1)	(1)	(1)	(1)	(1)
West Virginia	--	--	--	(1)	(1)	(1)
Undistributed	10,065	5,125	.509	41,907	31,935	.762
Total 1976[2]	10,065	5,125	.509	41,907	31,935	.762
At merchant plants	10,065	5,125	.509	6,785	3,318	.489
At furnace plants	(4)	(4)	(4)	35,122	28,618	.815
Total 1975	10,122	5,244	.518	13,322	5,834	.438

[1]Included with "Undistributed" to avoid disclosing individual company confidental data.
[2]Data may not add to totals shown because of independent rounding.
[3]Included with furnace plants to avoid disclosing individual company confidential data.
[4]Included with merchant plants to avoid disclosing individual company confidential data.

Table 39.—Coke-oven gas and other gases used in heating coke ovens in the United States in 1976, by State[1]

(Million cubic feet)

State	Coke-oven gas	Blast-furnace gas	Natural gas	Other	Total coke-oven gas equivalent
Alabama	33,339	--	1,087	--	34,427
California, Colorado, Utah	20,602	5,421	49	--	26,073
Illinois	12,170	15	--	--	12,185
Indiana	54,414	4,579	324	--	59,317
Kentucky, Missouri, Tennessee, Texas	9,247	21	11	--	9,279
Maryland and New York	40,386	5,481	4	--	45,871
Michigan	8,031	12,718	--	--	20,749
Minnesota and Wisconsin	5,000	--	--	--	5,000
Ohio	56,810	2,836	--	--	59,646
Pennsylvania	106,906	2,148	--	--	109,054
West Virginia	13,836	6,197	--	--	20,033
Total 1976[2]	360,742	39,416	1,476	--	401,634
At merchant plants	26,468	--	--	--	26,468
At furnace plants	334,275	39,416	1,476	--	375,166
Total 1975	354,569	35,442	683	3,037	393,731

[1]Adjusted to an equivalent of 550 Btu per cubic foot.
[2]Data may not add to totals shown because of independent rounding.

Table 40.—Coke-oven ammonia produced in the United States and sold in 1976 by State

(Thousand short tons and thousand dollars)

State	Active plants[1]	Produced: Sulfate equivalent	Produced: Pounds per ton of coal coked	Produced: As sulfate[2]	Produced: As liquor (NH_3 content)	Sold: As sulfate: Quantity	Sold: As sulfate: Value	Sold: As liquor (NH_3 content): Quantity	Sold: As liquor (NH_3 content): Value	Stocks, Dec. 31: As sulfate	Stocks, Dec. 31: As liquor (NH_3 content)
Alabama	7	59	18.02	59	--	67	2,285	--	--	5	--
California, Colorado, Utah	3	47	18.29	47	--	41	1,714	--	--	6	--
Illinois	4	15	11.16	15	--	21	874	--	--	1	--
Indiana and Michigan	6	113	14.07	108	(3)	117	10,432	(3)	(3)	14	(3)
Kentucky, Minnesota, Tennessee, Texas	4	10	14.18	7	(3)	7	286	(3)	(3)	1	(3)
Maryland and New York	4	78	18.10	77	(3)	91	3,909	(3)	(3)	2	(3)
Ohio	11	87	14.99	79	(3)	88	3,168	(3)	(3)	8	(3)
Pennsylvania	8	103	16.16	103	--	120	4,433	--	--	16	--
West Virginia	3	27	12.81	27	--	32	1,404	--	--	2	--
Undistributed	--	--	--	--	5	--	--	6	562	--	2
Total 1976[4]	50	539	15.64	522	5	585	28,504	6	562	55	2
At merchant plants	6	22	17.14	(5)	5	(5)	(5)	6	562	(5)	2
At furnace plants	44	517	15.58	522	(6)	585	28,504	(6)	(6)	55	(6)
Total 1975	51	534	15.98	511	6	410	32,010	8	742	122	2

[1]Number of plants that recovered ammonia.
[2]Includes diammonia phosphate to avoid disclosing individual company confidential data.
[3]Included with "Undistributed" to avoid disclosing individual company confidential data.
[4]Data may not add to totals shown because of independent rounding.
[5]Included with furnace plants to avoid disclosing individual company confidential data.
[6]Included with merchant plants to avoid disclosing individual company confidential data.

Table 41.—Coke-oven tar produced in the United States, used by producers, and sold in 1976, by State

(Thousand gallons)

State	Produced		Used by producers			Sold for refining into tar products			
	Total	Gallons per ton of coal coked	For refining or topping	As fuel	Otherwise	Quantity	Value		Stocks, Dec. 31
							Thousands	Average per gallon	
Alabama	42,756	6.49	(1)	(1)	--	26,328	$9,801	$0.372	2,618
California, Colorado, Utah	46,609	9.17	--	(1)	--	(2)	(2)	(2)	2,656
Illinois	16,991	6.13	--	(1)	--	41,678	13,393	.321	1,460
Indiana	86,584	7.06	(1)	27,943	--	29,671	10,112	.341	3,378
Kentucky, Missouri, Tennessee, Texas	10,759	5.62	--	(1)	--	10,782	3,547	.329	409
Maryland and New York	67,663	7.56	--	(1)	--	26,165	9,180	.351	5,911
Michigan	32,795	6.86	--	--	--	33,234	10,496	.316	2,878
Minnesota and Wisconsin	3,735	3.79	--	(1)	--	25,578	7,068	.276	650
Ohio	97,229	7.98	(1)	51,633	--	43,708	15,248	.349	6,198
Pennsylvania	191,955	8.33	(1)	42,781	(1)	53,393	17,572	.329	16,073
West Virginia	39,307	7.57	(1)	--	--	(3)	(3)	(3)	2,419
Undistributed	--	--	163,051	65,169	5,460	--	--	--	--
Total 1976[4]	636,382	7.60	163,051	187,526	5,460	290,536	96,417	.331	44,649
At merchant plants	30,898	5.26	(5)	--	--	30,134	10,799	.358	1,119
At furnace plants	605,484	7.77	163,051	187,526	5,460	260,402	85,618	.329	43,531
Total 1975	645,537	7.83	178,147	162,112	4,964	284,841	98,898	.347	[6]54,842

[1]Included with "Undistributed" to avoid disclosing individual company confidential data.
[2]Included with "Illinois" to avoid disclosing individual company confidential data.
[3]Included with "Minnesota and Wisconsin" to avoid disclosing individual company confidential data.
[4]Data may not add to totals shown because of independent rounding.
[5]Included with furnace plants to avoid disclosing individual company confidential data.
[6]Revised to reflect inventory adjustments.

Table 42.—Coke-oven crude light oil produced in the United States and derived products produced and sold in 1976, by State

(Thousand gallons)

State	Active plants[1]	Crude light oil				Derived products		
		Produced	Gallons per ton of coal	Refined on premises[2]	Stocks, Dec. 31	Produced	Sold[3]	
							Quantity	Value (thousands)
Alabama	7	12,620	1.92	--	1,341	477	427	$117
California, Colorado, Utah	3	15,772	3.10	8,489	283	6,460	6,293	4,639
Illinois	4	6,693	2.42	7	215	--	--	--
Indiana	4	22,379	2.39	358	472	(4)	(4)	(4)
Kentucky, Michigan, Missouri, Tennessee, Texas	5	11,078	1.93	1,049	379	1,004	1,025	647
Maryland and New York	4	25,448	2.84	14,177	1,124	12,344	12,382	9,895
Ohio	11	26,446	2.18	4,425	631	3,384	3,326	2,426
Pennsylvania	10	63,192	2.82	61,319	3,662	53,022	49,255	36,395
West Virginia	3	14,429	2.78	16	725	(4)	(4)	(4)
Total 1976[5]	51	198,056	2.53	89,841	8,831	76,692	72,708	54,118
At merchant plants	6	6,298	1.67	368	785	263	268	164
At furnace plants	45	191,758	2.58	89,473	8,046	76,429	72,439	53,955
Total 1975	51	194,814	2.55	95,178	[6]5,261	82,308	81,885	57,419

[1]Number of plants that recovered crude light oil.
[2]Includes small quantity of material also reported in sales of crude light oil in table 33.
[3]Excludes 104,645,000 gallons of crude light oil valued at $52,532,000 sold as such.
[4]Included with Maryland and New York.
[5]Data may not add to totals shown because of independent rounding.
[6]Revised to reflect inventory adjustments.

Table 43.—Yield of light oil derivatives from refining crude light oil at oven-coke plants in the United States

(Percent)

Year	Benzene (all grades)	Toluene (all grades)	Xylene (all grades)	Solvent naphtha (crude and refined)	Other light oil products
1972	59.3	12.8	3.1	3.0	4.7
1973	61.2	11.3	2.8	2.7	5.5
1974	60.2	11.5	2.7	2.9	4.7
1975	61.0	11.7	2.1	2.5	5.5
1976	58.8	10.6	1.8	2.8	5.1

Table 44.—Benzene and toluene produced at oven-coke plants in the United States, by grade

(Thousand gallons)

Year	Benzene: Specification grades (1°, 2°, 90%)	Benzene: Other industrial grades	Toluene (all grades)
1972	76,317	3,532	14,571
1973	[r]85,876	3,299	14,496
1974	82,149	([1])	13,567
1975	65,050	([1])	9,841
1976	60,411	([1])	8,824

[r]Revised.

[1]Included with "Specification grades" to avoid disclosing individual company confidential data.

Table 45.—Light oil derivatives produced at oven-coke plants in the United States and sold in 1976, by State

(Thousand gallons and thousand dollars)

State	Benzene (all grades) Produced	Benzene Yield from crude light oil refined (percent)	Benzene Sold Quantity	Benzene Sold Value	Toluene (all grades) Produced	Toluene Yield from crude light oil refined (percent)	Toluene Sold Quantity	Toluene Sold Value
Colorado, Indiana, Utah	(1)	(1)	(1)	(1)	(2)	(2)	(2)	(2)
Maryland and Texas	17,200	72.6	17,412	14,005	(2)	(2)	(2)	(2)
Ohio	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Pennsylvania	43,211	54.7	42,409	33,521	8,824	10.6	8,446	4,642
Total 1976[3] [4]	60,411	58.8	59,822	47,526	8,824	10.6	8,446	4,642
Total 1975	65,050	61.0	66,283	49,724	9,841	11.7	10,455	5,539

State	Xylene (all grades) Produced	Xylene Yield from crude light oil refined (percent)	Xylene Sold Quantity	Xylene Sold Value	Solvent naphtha (crude and refined) Produced	Solvent naphtha Yield from crude light oil refined (percent)	Solvent naphtha Sold Quantity	Solvent naphtha Sold Value
Colorado, Indiana, Utah	(1)	(1)	(1)	(1)	(2)	(2)	(2)	(2)
Maryland and Texas	263	1.2	261	153	(2)	(2)	(2)	(2)
Ohio	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Pennsylvania	1,233	2.0	990	579	1,968	2.8	1,792	713
Total 1976[3] [5]	1,496	1.8	1,251	732	1,968	2.8	1,792	713
Total 1975	1,884	2.1	1,958	1,083	2,045	2.5	1,947	652

[1]Included with New York and Texas to avoid disclosing individual company confidential data.
[2]Included with Pennsylvania to avoid disclosing individual company confidential data.
[3]Data may not add to totals shown because of independent rounding.
[4]All furnace plants.
[5]Data not broken down into merchant and furnace plants to avoid disclosing individual company confidential data.

Columbium and Tantalum

By Henry E. Stipp[1]

U.S. consumption of ferrocolumbium, ferrotantalum-columbium, and other columbium and tantalum materials totaled approximately 3.4 million pounds of contained columbium and tantalum, compared with consumption of 3.3 million pounds in 1975. Ferrocolumbium and other columbium and tantalum materials were consumed mainly in producing specialty steels and superalloys.

Consumption of columbium raw materials increased to approximately 3.4 million pounds of contained columbium compared with 2.1 million pounds in 1975.

Reported consumption of tantalum contained in raw materials increased to about 2.0 million pounds contrasted with the 1.1 million pounds in 1975. Increased demand for tantalum electronic capacitors for use in citizen band radios, smoke detector devices, heart pacemakers, and automobiles was reported to be the main reason for the rise in tantalum consumption.

Columbium mineral concentrates imported for consumption increased sharply to 3,968,000 pounds, gross weight (1,595,000 pounds contained columbium and 118,000 pounds contained tantalum). In 1975 columbium mineral concentrates imported for consumption totaled 1,542,000 pounds, gross weight (606,000 pounds contained columbium and 47,000 pounds contained tantalum). Tantalum mineral concentrates (including synthetic concentrates) imported for consumption increased to 2,557,000 pounds, gross weight (709,000 pounds contained tantalum, and 606,000 pounds contained columbium), compared with 1,753,000 pounds, gross weight (584,000 pounds contained tantalum, and 239,000 pounds contained columbium) in 1975. Imports of columbium concentrates in 1976 came mainly from Brazil, 47%; Canada, 30%; Nigeria, 12%; the People's Republic of China, 5%; Malaysia, 4%; and others, 2%. Tantalum concentrates came chiefly from West Germany, 42%; Canada, 20%; Australia, 9%; Thailand, 8%; Zaire, 6%; Brazil, 6%; and others, 9%.

Legislation and Government Programs.—Sales in 1976 of columbium materials from U.S. Government stockpile excesses by the General Services Administration (GSA) totaled 68,908 pounds of contained columbium in columbium concentrates. There were no sales of tantalum materials. Columbium concentrates shipped from U.S. Government stockpile excesses totaled 70,089 pounds of contained columbium; tantalum concentrates shipments were 8,028 pounds of contained tantalum. On October 1, the Federal Preparedness Agency (FPA) of GSA announced new stockpile goals, which were to be updated as necessary. These new goals for columbium and tantalum are shown in table 3 but are subject to change.

In an investigation started on August 3, 1976, the U.S. International Trade Commission determined that the U.S. tantalum industry was not being injured and was not likely to be by the importation of tantalum electrolytic fixed capacitors from Japan (other than those produced and sold by Matsushita Electric Industrial Co. Ltd.).[2]

[1]Physical scientist, Division of Ferrous Metals.
[2]U.S. International Trade Commission (USITC). Tantalum Electrolytic Fixed Capacitors. Determination of No Injury or Likelihood Thereof in Investigation No. AA 1921-159 Under the Anti-dumping Act of 1921, as Amended, Together With the Information Obtained in the Investigation. USITC Publication 789. Washington, D.C., October 1976, 96 pp.

Table 1.—Salient columbium statistics

(Thousand pounds)

	1972	1973	1974	1975	1976
United States:					
Mine production of columbite-tantalite concentrates	--	--	--	--	--
Releases from Government excesses (Cb content)[1]	799	2,344	2,739	463	70
Consumption of raw materials (Cb content)	2,489	2,806	3,250	2,137	3,379
Production of primary products:					
Columbium metal (Cb content)	W	W	W	W	W
Ferrocolumbium (Cb content)	1,474	1,496	1,917	e985	1,565
Consumption of primary products:					
Columbium metal (Cb content)	218	254	221	130	291
Ferrocolumbium, ferrotantalum-columbium and other columbium and tantalum materials (Cb and Ta content)	3,676	4,056	4,626	3,348	3,389
Exports: Columbium metal, compounds, and alloys (gross weight)	29	96	33	53	67
Imports for consumption:					
Mineral concentrate (Cb content)	1,558	1,314	r1,583	r845	2,201
Columbium metal and columbium-bearing alloys (Cb content)	1	4	1	3	--
Ferrocolumbium (Cb content)e	1,530	2,120	3,276	1,872	2,221
Tin slags (Cb content)[2]	547	603	460	144	296
World: Production of columbium-tantalum concentrates (Cb content)e	13,121	32,452	r20,597	r12,533	19,648

eEstimate. rRevised. W Withheld to avoid disclosing individual company confidential data.
[1]Includes columbium content in raw materials from which columbium is not recovered and material released as payment-in-kind for upgrading.
[2]Receipts reported by consumers.

Table 2.—Salient tantalum statistics

(Thousand pounds)

	1972	1973	1974	1975	1976
United States:					
Mine production of columbium-tantalum concentrates	--	--	--	--	--
Releases from Government excesses (Ta content)[1]	87	266	884	87	8
Consumption of raw materials (Ta content)	1,280	2,221	2,425	1,077	2,005
Production of primary metal (Ta content)	1,352	1,619	1,849	844	1,873
Consumption of primary products:					
Tantalum metal (Ta content)	922	1,096	1,159	450	1,098
Ferrocolumbium and ferrotantalum-columbium and other columbium and tantalum materials (Cb and Ta content)	3,676	4,056	4,626	3,348	3,389
Exports:					
Tantalum ore and concentrate (gross weight)	19	16	201	60	59
Tantalum metal, compounds, and alloys (gross weight)	146	344	503	471	367
Tantalum and tantalum alloy powder (Ta content)	171	202	233	161	219
Imports for consumption:					
Mineral concentrate (Ta content)	458	428	r786	r631	827
Tantalum metal and tantalum-bearing alloys (Ta content)	74	101	184	66	52
Tin slags (Ta content)[2]	625	719	760	r236	431
World: Production of columbium-tantalum concentrates (Ta content)e	818	847	r962	r907	855

eEstimate. rRevised.
[1]Includes material released as payment-in-kind for upgrading.
[2]Receipts reported by consumers.

Table 3.—Columbium and tantalum materials in Government inventories as of Dec. 31, 1976

(Thousand pounds, columbium or tantalum content)

Material	Stockpile goals[1]	National (strategic) stockpile	Defense Production Act (DPA) inventory	Supple-mental stockpile	Total
Columbium:					
Concentrates	3,131	1,781	--	--	1,781
Carbide powder: Stockpile grade	--	21	--	--	21
Ferrocolumbium:					
Stockpile grade	--	598	--	--	598
Nonstockpile grade	--	333	--	--	333
Metal: Stockpile grade	--	45	--	--	45
Tantalum:					
Tantalum minerals: Stockpile grade	5,452	2,548	--	--	2,548
Carbide powder: Stockpile grade	889	29	--	--	29
Metal: Stockpile grade	1,650	201	--	--	201

[1]Stockpile goals established as of Oct. 1, 1976.

DOMESTIC PRODUCTION

There was no domestic production of columbium and tantalum minerals reported in 1976. However, Buttes Gas & Oil Co. was investigating a large titanium deposit in the Powderhorn area of Southwestern Colorado. The deposit reportedly contains significant quantities of columbium in the form of the mineral perovskite.

Tantalum metal powder (including capacitor-grade powder) produced from imported concentrates increased in quantity to 1,873,000 pounds compared with 844,000 pounds in 1975. Demand for tantalum powder for use in electronic capacitors was mainly responsible for the increased tantalum metal production. Production of tantalum metal ingots increased to 576,000 pounds, a 57% increase over the 367,000 pounds of 1975.

Columbium metal production data were withheld to avoid disclosing individual company confidential information. Data on production of columbium metal ingot also were withheld for the same reason. Four domestic companies produced 1,565,000 pounds of contained columbium in ferrocolumbium, valued at about $6.4 million.

Molycorp, Inc. at White Plains, N.Y., proposed to purchase about 1 million shares (32%) of the common stock of Kawecki-Berylco Industries, Inc. (KBI). At yearend Molycorp announced that it controlled 49.7% of the common stock of KBI.[3]

A new 1,200-kilowatt electron beam furnace was placed in operation at the Boyertown, Pa., plant of KBI, increasing capacity to produce ingots of high-quality electronic- and metallurgical-grade columbium and tantalum metal and their alloys.

H. K. Porter Co., Inc. of Pittsburgh, Pa., acquired 85% of the common stock of Fansteel, Inc., Chicago, Ill., manufacturers of columbium, tantalum, and their alloys.[4]

Norton Co., Newton, Mass., sold its metals division, a large producer of tantalum metal and mill products, to NRC Inc., a corporation jointly owned by Herman C. Starck, Berlin, West Germany, and Samincorp Inc., New York, N.Y. Samincorp is a subsidiary of South American Consolidated Enterprises, S.A., and Starck is a European manufacturer of special metals and alloys.[5]

KBI and Herman C. Starck contracted for Starck to process tin slags, owned by KBI, for consumption in Kawecki's plant at Boyertown, Pa.[6]

[3]The Wall Street Journal. Kawecki-Berylco's Board Stays Neutral on Bid by Molycorp. V. 18, No. 24, Aug. 4, 1976, p. 7.

[4]American Metal Market. H. K. Porter Execs on Fansteel Board. V. 83, No. 136, July 13, 1976, p. 21.

[5]American Metal Market. Norton Sells Metals Division to NRC. V. 83, No. 61, Mar. 29, 1976, pp. 2, 53.

[6]American Metal Market. West German Firm To Recycle KBI's Tantalum Tin Slag. V. 82, No. 193, Oct. 1, 1976, p. 2.

Table 4.—Major domestic columbium and tantalum processing and producing companies in 1976

Company	Location	Columbium	Tantalum	Tantalum carbide	Ferrocolumbium
Fansteel, Inc	Chicago, Ill	X	X	X	--
	Muskogee, Okla	X	X	X	--
General Electric Co	Warren, Mich	--	--	X	--
Kawecki Div., Kawecki-Berylco Industries, Inc.	Boyertown, Pa	X	X	X	X
Kennametal, Inc	Latrobe, Pa	X	X	X	--
Mallinckrodt, Inc	St. Louis, Mo	X	X	--	--
NRC Inc	Newton, Mass	X	X	X	--
Newcomer Products, Inc	Latrobe, Pa	X	--	X	--
Reading Alloys Co., Inc	Robesonia, Pa	X	--	--	X
Shieldalloy Corp	Newfield, N.J	X	--	--	X
Wah Chang Albany (a Teledyne company).	Albany, Oreg	X	X	X	X

CONSUMPTION AND USES

Primary columbium metal consumption increased 124% to 291,000 pounds compared with 130,000 pounds in 1975. High-purity columbium metal in powder and ingot form was used mainly in preparing superalloys for the aerospace industry.

Tantalum metal consumption, including capacitor-grade powder, increased 144% to 1,098,000 pounds. In 1975 approximately 450,000 pounds of tantalum metal was consumed. The principal end use for tantalum metal powder was in the manufacture of capacitors for use by the electronics industry. Tantalum metal ingot was used mainly to fabricate corrosion-resistant chemical equipment.

Approximately 89% of the ferrocolumbium consumed in 1976 was added to alloy steels such as high-strength, low-alloy (HSLA) steels for the manufacture of oil and gas pipelines, structural steel, plate for ships, machinery, automobiles and atomic reactor steels. Construction of pipelines in the market economy countries during 1976 reportedly increased 45% above the annual average mileage for the previous 5 years. New pipelines in 1976 were estimated to cost a record $6.76 billion, a 48% increase over that of 1975.[7]

[7]Oil and Gas Journal. Spending for New Lines To Break All Records in 1976. V. 74, No. 4, Jan. 26, 1976, p. 73.

Table 5.—Reported shipments of columbium and tantalum materials

(Pounds of metal content)

Material	1975	1976	Change (percent)
Columbium products:			
Compounds, including alloys	930,800	791,300	-15
Metal, including worked products	112,700	101,600	-10
All other	21,200	41,000	+93
Total columbium	1,064,700	933,900	-12
Tantalum products:			
Oxides and salts	127,400	55,400	-57
Alloy additive	8,500	13,200	+55
Carbide	106,500	93,300	-12
Powder and anodes	436,600	759,000	+74
Ingot (unworked consolidated metal)	1,000	7,700	+670
Mill products	172,000	238,500	+39
Scrap	13,000	130,700	+905
Total tantalum	865,000	1,297,800	+50

Source: Tantalum Producers Association.

Specialty steel producers reported that sales in the aircraft engine market during 1976 were slow, but a pickup was expected during the first quarter of 1977. However, some producers reported an increase in demand for specialty steel in the nuclear reactor field during the second half of 1976.

An area of potential growth in consumption of columbium is in nickel- and cobalt-based alloys for use in automobile turbine engines. Superalloys containing columbium were used for aircraft turbines and nuclear powerplants.

A report by engineers of a major automobile manufacturer listed a number of unusual applications for HSLA steel that included door panels, front suspension cross members, idler arm brackets, and rear anchor cross members. However, widespread use of HSLA steel in automobile body applications has been slowed in favor of increased use of nitrogenized or strain aging steel. Reportedly, nitrogenized steel is more economical to use and more adaptable to conventional manufacturing techniques.[8]

Table 6.—Consumption of ferrocolumbium, ferrotantalum-columbium, and other columbium and tantalum materials in the United States in 1976, by end use

(Pounds)

End use	Contained columbium and tantalum
Steel:	
Carbon	885,053
Stainless and heat-resisting	459,077
Full alloy	527,496
High-strength, low-alloy	996,479
Electric	--
Tool	W
Unspecified	43,791
Total steel	2,911,896
Superalloys	421,711
Alloys (exclude alloy steels and superalloys)	49,887
Miscellaneous and unspecified	5,785
Total	3,389,279

W Withheld to avoid disclosing individual company confidential data; included with "Steel: Unspecified."

STOCKS

Processor and dealer inventories of columbium and tantalum materials at yearend were as follows, in pounds, contained columbium (Cb) and tantalum (Ta):

Material	Dec. 31, 1975	Dec. 31, 1976
COLUMBIUM		
Primary metal	54,560	81,401
Ingot	33,344	65,902
Scrap	55,453	106,958
Oxide	r663,584	524,579
Other compounds	r14,279	14,515
TANTALUM		
Primary metal	232,003	302,274
Capacitor-grade powder	97,457	94,088
Ingot	84,527	114,349
Scrap	312,960	174,457
Oxide	r61,394	49,174
Potassium tantalum fluoride	r45,409	88,572
Other compounds	r45,080	45,028

rRevised.

Stocks of columbium and tantalum raw materials reported by processors and dealers at yearend 1976, in thousand pounds of contained Cb or Ta (yearend 1975 figures in parentheses), were as follows: Columbite, Cb-491, Ta-465 (Cb-552, Ta-69); tantalite, Ta-424, Cb-206 (Ta-976, Cb-545); tin slag, Ta-2,431, Cb-1,946 (Ta-2,667, Cb-2,092); pyrochlore, Cb-143, Ta— (Cb-28, Ta—).

Consumer stocks of ferrocolumbium, ferrotantalum-columbium, and other columbium and tantalum materials as of December 31, 1976, were as follows, in pounds of contained Cb and Ta (stocks on December 31, 1975 in parentheses): Ferrocolumbium—923,655 (1,091,372); ferrotantalum-columbium—8,589 (10,500); and other columbium and tantalum materials—30,361 (30,744). Producer stocks of ferrocolumbium at yearend 1976 were 794,612 (1,077,500).

[8]American Metal Market. Nitrogenized Steels Capturing Automotive Favor for Body Use. V. 83, No. 51, Mar. 15, 1976, p. 13.

PRICES

Columbite and pyrochlore prices increased in 1976 mainly because of higher costs for mining and processing. Contract prices for Canadian pyrochlore, f.o.b. mine and mill, increased from the \$1.56 per pound of contained Cb_2O_5, that carried over from that of 1975, to about \$1.75 to \$1.85 per pound of Cb_2O_5 on March 11, and for the rest of the year they were quoted as nominal or about \$2.00 to \$2.25 per pound Cb_2O_5. Spot columbite concentrate prices, c.i.f., U.S. ports, increased from the \$1.80 to \$1.90 per pound of contained pentoxides, that was quoted on January 1, for material having a Cb_2O_5 to Ta_2O_5 ratio of 10 to 1, to \$2.40 to \$2.60 per pound of contained Cb_2O_5 and Ta_2O_5 on February 5; and to \$2.40 to \$2.70 per pound of contained Cb_2O_5 and Ta_2O_5 on May 21. On November 11 prices for spot columbite concentrate increased further to \$3.00 to \$3.50 per pound of contained Cb_2O_5 and Ta_2O_5.

U. S. reactor-grade columbium metal ingot prices were \$18.00 to \$25.00 per pound of columbium throughout the year; U.S. reactor-grade columbium metal powder was priced at \$30.00 to \$45.00 during 1976.

Ferrocolumbium prices per pound of contained columbium, ton lots, f.o.b. shipping point, were as follows on January 1: Spot, low-alloy, \$4.30 per pound; high-purity grade, \$8.61 to \$9.50 per pound. On July 1, the spot price for low-alloy ferrocolumbium increased to \$4.73 per pound and remained at that price for the rest of the year. On July 1, the price for high-purity grade ferrocolumbium increased to \$10.90 to \$11.83 per pound and on October 18 increased again to \$11.80 to \$14.30 and remained in that range for the remainder of the year.

On January 1 the price of nickel columbium increased to \$11.35 per pound of contained Cb, from \$10.40 per pound at yearend 1975. Effective October 18, the price of nickel columbium moved to \$14.30 per pound of contained Cb and remained at that price for the remainder of 1976.

Spot tantalite ore was quoted at \$15.50 to 16.50 per pound of contained Ta_2O_5, 60% basis, c.i.f. U.S. ports, at the beginning of the year. On June 18, the price advanced to \$16.00 to \$17.25 per pound; on November 11, the price increased further to \$17.25 to \$18.00 per pound and remained at that price for the rest of the year. Tantalum Mining Corporation of Canada (Tanco) tantalite was quoted at \$16.00 per pound of contained Ta_2O_5 throughout the year. Thailand tin slags were quoted as nominal throughout the year.

U.S. grade tantalum metal powder was listed at \$35.40 to \$48.00 per pound of tantalum throughout 1976, U.S. grade tantalum metal rod was quoted at \$52.00 to \$80.00 per pound, and U.S. tantalum metal sheet was quoted at \$48.00 to \$118.00 per pound throughout the year.

On November 1 the price of tantalum carbide increased to \$33.50 to \$34.50 per pound from the \$30.25 per pound that carried over from that of 1975.

Table 7.—Average grade of concentrate received by U.S. consumers and dealers in 1976, by country of origin

(Percent contained pentoxides)

Country	Columbite		Tantalite	
	Cb_2O_5	Ta_2O_5	Ta_2O_5	Cb_2O_5
Australia	--	--	39	36
Brazil, pyrochlore	58	--	--	--
Brazil, columbite and tantalite	50	21	36	32
Canada	59	--	51	4
Germany, West	--	--	24	47
Malaysia	60	15	33	20
Mozambique	--	--	54	19
Nigeria	63	7	--	--
Portugal	43	6	--	--
Rwanda	50	24	29	42
South Africa, Republic of	--	--	35	35
Spain	34	26	31	30
Thailand	--	--	33	30
Zaire	46	30	32	39

FOREIGN TRADE

Unwrought columbium and columbium alloys, waste and scrap exported from the United States went mainly to West Germany (69%) and the United Kingdom (27%). Wrought columbium and columbium alloys were exported from the United States chiefly to the Netherlands (44%), Canada (17%), the United Kingdom (11%), West Germany (9%), and Japan (7%).

Tantalum ores and concentrates were exported from the United States mainly to West Germany (60%) and Japan (40%). U.S. exports of unwrought tantalum metal, alloys, and waste and scrap were shipped for the most part to West Germany (64%), the United Kingdom (18%), and Japan (14%). Tantalum metal powder and tantalum-alloy powder exports went mainly to West Germany (36%), Japan (34%), and the United Kingdom (13%). U.S. exports of wrought tantalum and tantalum alloys went chiefly to West Germany (31%), Japan (28%), the United Kingdom (22%), and France (4%).

Unwrought columbium metal, waste and scrap imports, all from West Germany, totaled 72 pounds valued at $2,765. Wrought columbium metal imported was not significant (1 pound). There were no U.S. imports of unwrought columbium alloys.

U.S. imports for consumption of unwrought tantalum metal, waste and scrap totaled 97,100 pounds valued at about $2.1 million, mainly from West Germany (57%), Mexico (18%), and France (9%). Wrought tantalum metal imports, chiefly from Belgium (80%) and Austria (12%), were 1,861 pounds valued at $158,560. There were no imports of unwrought tantalum alloys in 1976.

Columbium mineral concentrates imported for consumption increased 157% (gross weight) compared with those of 1975. Imports for consumption of tantalum mineral concentrates increased 46% (gross weight) compared with those of 1975.

Imports of tin slags, which increased 92%, gross weight, over those of 1975, came chiefly from Thailand and Malaysia.

Table 8.—U.S. exports of columbium and tantalum, by class

(Thousand pounds, gross weight, and thousand dollars)

Class	1975		1976	
	Quantity	Value	Quantity	Value
Columbium and columbium alloys, unwrought, and waste and scrap	17	61	24	175
Columbium and columbium alloys, wrought	36	726	43	604
Tantalum ores and concentrates	60	165	59	317
Tantalum and tantalum alloys, wrought	34	1,928	45	2,571
Tantalum metals and alloys, in crude form and scrap	437	3,452	322	3,823
Tantalum and tantalum alloy powder	161	5,974	219	7,982

Table 9.—Receipts of tin slags reported by consumers

(Thousand pounds)

Year	Gross weight	Cb_2O_5 content	Ta_2O_5 content
1972	9,709	780	741
1973	8,607	863	878
1974	8,207	657	910
1975	2,283	205	288
1976	4,373	424	523

Table 10.—U.S. imports for consumption of columbium-mineral concentrates, by country

(Thousand pounds and thousand dollars)

	1975				1976			
	Gross weight	Cb[e] content	Ta[e] content	Value	Gross weight	Cb[e] content	Ta[e] content	Value
Brazil	1,135	460	--	1,215	1,868	757	--	2,300
Canada	21	7	--	22	1,196	493	--	1,797
China, People's Republic of	9	2	2	10	179	44	51	232
Germany, West	--	--	--	--	23	7	4	67
Malaysia	138	49	21	313	157	66	19	361
Nigeria	151	66	10	166	477	210	27	800
Portugal	16	4	5	54	--	--	--	--
South Africa, Republic of	2	([1])	([1])	10	--	--	--	--
Spain	11	3	2	55	11	3	2	55
Taiwan	--	--	--	--	40	10	11	53
Thailand	44	12	7	122	5	1	1	19
Zaire	15	3	--	45	13	4	3	53
Total	1,542	606	47	2,012	[2]3,968	1,595	118	5,737

[e]Estimated by Bureau of Mines.
[1]Less than 1/2 unit.
[2]Data do not add to total shown because of independent rounding.

Table 11.—U.S. imports for consumption of tantalum-mineral concentrates, by country

(Thousand pounds and thousand dollars)

	1975				1976			
	Gross weight	Cb[e] content	Ta[e] content	Value	Gross weight	Cb[e] content	Ta[e] content	Value
Australia	203	20	66	1,156	229	58	73	1,674
Belgium-Luxembourg[1]	7	--	--	36	1	([2])	([2])	7
Brazil	151	29	44	526	148	33	44	689
Canada	664	19	279	3,471	499	14	208	2,537
China, People's Republic of	--	--	--	--	5	1	1	3
France	--	--	--	--	2	1	1	32
Germany, West[3]	[r]162	[r]32	[r]47	[r]681	1,067	359	213	7,679
Kenya	7	1	2	31	--	--	--	--
Malaysia	86	27	16	146	22	3	6	49
Mozambique	66	9	29	452	53	7	23	480
Netherlands	7	([2])	2	54	22	5	6	117
Portugal	15	3	4	60	--	--	--	--
Rhodesia	12	1	3	58	--	--	--	--
Rwanda	87	25	20	202	99	29	24	267
South Africa, Republic of	--	--	--	--	9	2	3	40
Spain	45	10	11	166	40	8	10	188
Tanzania	--	--	--	--	7	2	2	24
Thailand	81	20	19	190	199	42	54	723
Uganda	11	3	2	28	--	--	--	--
Zaire	149	40	40	537	156	42	41	615
Total	[r]1,753	[r]239	[r]584	[r]7,794	[4]2,557	606	709	15,124

[e]Estimated by Bureau of Mines. [r]Revised.
[1]Presumably country of transshipment rather than original source.
[2]Less than 1/2 unit.
[3]Includes synthetic concentrates.
[4]Data do not add to total shown because of independent rounding.

WORLD REVIEW

Austria.—Treibacher Chemische Werke AG, Treibach, appointed Metallurgical International Inc., Tinton Falls, N.J., exclusive sales agent in the United States for its cemented carbide cutting tools, mining tools, and wear parts. Treibacher employs 1,300 people manufacturing carbides of columbium, tantalum, vanadium, tungsten, molybdenum, and titanium. The company also produces optical pure tantalum oxide, columbium oxide, ferroalloys, abrasives, hard metals, and detergents.[9]

Brazil.—In 1975 Companhía Brasileira de Metalurgia e Mineração (CBMM) produced 21.5 million pounds of pyrochlore concentrate containing an estimated 12.5 million pounds Cb_2O_5. The company also produced about 9 million pounds of ferrocolumbium containing almost 5.9 million pounds of columbium. In 1976 CBMM produced 23 million pounds Cb_2O_5 valued at $31.6 million. Production of ferrocolumbium was about 12 million pounds containing about 7.5 million pounds of columbium.

Production of tantalite in 1975 by a number of small producers totaled 209,437 pounds containing approximately 75,400 pounds Ta_2O_5 and 56,550 pounds Cb_2O_5.

The concentrating plant of CBMM located next to the pyrochlore mine, about 5 miles south of the city of Araxá in Minas Gerais, currently has the capacity of producing about 53 million pounds of pyrochlore concentrate per year containing about 28 million pounds Cb_2O_5. The concentrate is converted into ferrocolumbium in CBMM's metallurgical plant located in the same industrial complex. The metallurgical plant has the capacity to produce about 26.5 million pounds of ferrocolumbium containing around 17.2 million pounds of columbium.[10]

A deposit containing from 25 million to 30 million tons of manganese ore with associated columbium reportedly was discovered at Morro de Sete Lagoas in the Uapes district near the Venezuelan border.[11]

The tantalum resources of Brazil were described by region, and reserves for the State of Minas Gerais were reported. According to the National Department of Mineral Production of Brazil, proven reserves of tantalite ore in the State of Minas Gerais in 1973 were 47,822 short tons, and indicated reserves were 80,050 tons. No information was available on reserves in other regions of Brazil. It was concluded that currently worked deposits were nearing depletion, but output could be expected to continue from other areas that contain numerous pegmatite dikes and alluvial gravels favorable for the occurrence of columbite and tantalite.[12]

Brasimet Commercio e Industria, S.A., shipped pyrochlore concentrates to European consumers in July. At yearend a 3,307 short-ton-per-year ferrocolumbium plant, located at Catalão, Goías State, was scheduled to begin operating.[13]

Canada.—Tanco was operating profitably although earnings reportedly were badly hit in 1976 by a strike, which lasted for several months. However, Tanco produced 281,777 pounds Ta_2O_5 valued at $3.5 million. Exploratory drilling added 175,000 short tons of ore grading 0.203% Ta_2O_5 to reserves, which were considered sufficient to last to 1980 at current rates of depletion.[14]

Reportedly the Manitoba Development Corp., an agency of the Manitoba Government, was considering purchase of the shares of stock of Tanco held by International Chemalloy Corp. The Manitoba Corp. currently holds a 25% interest in Tanco, Chemalloy Minerals Ltd. has a 50.1% interest, and KBI holds a 24.9% interest.[15]

St. Lawrence Columbium & Metals Corp. closed its mine and mill in early February, reportedly because of a strike by underground workers. In late June the company went into receivership. At yearend the mine, mill, and equipment were put up for sale.[16]

The pyrochlore mine of Niobec Inc. located near Chicoutimi, Quebec, was officially opened on June 7. Two shipments of concentrate were made in May, but it was expected that the mill would take 6 months to reach

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[9]American Metal Market. Metallurgical International Markets Complex Carbides for Tool Making. V. 82, No. 230, Nov. 29, 1976, p. 25.

[10]Siderurgia Latinoamericana. CBMM, Worldwide Supplier of Ferroniobium and Pyrochlore Concentrate. No. 191, March 1976, pp. 31-33.

[11]Engineering and Mining Journal. Brazil. V. 177, No. 3, March 1976, p. 136.

[12]Tantalum Producers International Study Center (TIC). The Tantalum Resources of Brazil. Quart. Bull. No. 9, February 1977, p. 2.

[13]Metals Week. Insider Report. V. 47, No. 48, Nov. 29, 1976, p. 2.

[14]The Northern Miner. Officials Seek To Unravel the Tangled Affairs and Raise Funds for International Chemalloy. V. 62, No. 35, Nov. 11, 1976. p. 21.

[15]The Northern Miner. MDC Considers Purchase Tanco Shares. V. 62, No. 13, June 10, 1976, pp. 1, 11.

[16]The Northern Miner. St. Lawrence Columbium Lining Up Support. V. 62, No. 46, Jan. 27, 1977, p. 1.

optimum operating capacity.[17]

Germany, West.—Patents owned by Herman C. Starck on an economical process for recovering tantalum from low-grade slags could give its U.S. affiliate NRC Inc. an advantage in the world tantalum market. This could be significant if reserves of tantalite ore become scarce after 1980.

Japan.—Mitsui Mining and Smelting Corp. was scheduled to start production of tantalum metal powder early in 1977. Mitsui purchased equipment and technology from Shinetsu Chemical Industry, which stopped producing tantalum metal powder in May 1976. Tantalum concentrates will be purchased by Mitsui from Australia, and tantalum slags, from Thailand and Malaysia. The company produced tantalum oxide in a plant rated at 7 tons per month in 1976.[18]

[17]The Northern Miner. Teck Earnings Pickup in Last Half To Overcome Tax and Royalty Bite. V. 62, No. 12, June 3, 1976, pp. 1, 11.

[18]Metal Bulletin (London). Mitsui Into Ta. No. 6132, Oct. 8, 1976, p. 25.

Table 12.— Columbium and tantalum: World production of mineral concentrates by country[1]

(Thousand pounds)

Country[2]	Gross weight[3]			Columbium content[4]			Tantalum content[4]		
	1974	1975	1976[p]	1974	1975	1976[p]	1974	1975	1976[p]
Argentina:									
Columbite	[r]2	[r] [e]2	[e]2	[5]1	[e]1	[e]1	[e]1	[e]1	[e]1
Tantalite	1	[e]1	[e]1	([6])	[e]([6])	[e]([6])	[5]1	[e]1	[e]1
Australia: Columbite-tantalite	[r]238	[7]291	[e]280	[r]40	29	[e]70	[r]90	95	[e]90
Brazil:									
Columbite-tantalite	203	220	276	47	42	62	75	65	81
Pyrochlore	39,414	21,466	[e]39,665	[r]16,138	[r]8,703	[e]16,077	--	--	--
Canada:									
Pyrochlore	[r] [e]8,500	[r] [e]7,500	[e]7,500	[5]2,959	[5]2,560	[5]2,560	--	--	--
Tantalite	[r] [e]820	[r] [e]740	[e]770	[e]32	[e]30	[e]31	[5]360	[5]325	[e]330
Malaysia: Colombite-tantalite	[r]205	110	101	[r]70	39	43	[r]22	17	12
Mozambique:									
Tantalite	[r]101	101	[e]100	[r]30	13	[e]13	[r]28	45	[e]45
Microlite	[r]137	97	[e]100	5	4	[e]4	[r]75	53	[e]50
Nigeria:									
Columbite	2,631	2,183	1,433	1,121	960	631	147	144	82
Tantalite	1	3	[e]2	([6])	[e]1	[e]1	([6])	[e]1	[e]1
Portugal: Tantalite	20	24	11	5	6	3	5	6	3
Rhodesia: Columbite-tantalite[e]	90	90	90	17	10	10	27	25	25
Rwanda: Columbite-tantalite	[r]165	103	100	[r]50	29	29	[r]41	23	24
South Africa, Republic of: Tantalite	1	--	--	([6])	--	--	([6])	--	--
Thailand:									
Columbite	[r]22	15	[e]15	[r]6	4	[e]4	[r]4	3	[e]3
Tantalite	[r]181	227	[e]220	[r]34	54	[e]60	[r]49	54	[e]60
Uganda: Columbite-tantalite[e]	8	5	5	[r]2	1	1	[r]2	1	1
Zaire: Columbite-tantalite	140	176	174	[r]40	47	48	35	48	46
Total	[r]52,880	33,354	50,845	[r]20,597	12,533	19,648	[r]962	907	855

[e]Estimate. [p]Preliminary. [r]Revised.

[1]Excludes columbium and tantalum-bearing tin concentrates and slag.

[2]In addition to the countries listed, Burundi, Spain, the Territory of South-West Africa, the U.S.S.R. and Zambia also produced or are believed to produce columbium and tantalum mineral concentrates, but information is unavailable to make adequate estimates of output levels.

[3]Data on gross weight generally has been presented as reported in sources, divided into concentrates of columbite, tantalite, pyrochlore, and microlite where information is available to do so, and reported in groups such as columbite-tantalite where it is not.

[4]Unless otherwise specified, content is estimated on the basis of the content reported for United States imports from the country in question. Estimates specifically marked as estimates are based on an estimated gross weight.

[5]Content calculated in terms of metal from data reported in source publication in terms of contained pentoxide.

[6]Less than 1/2 unit.

TECHNOLOGY

High-purity single crystals of tantalum were deformed under tension and compression at 4.2 kelvin in order to determine the type of deformation that occurred. In tension the principal mode of deformation of pure tantalum was slip, whereas in compression it was twinning. The addition of up to 4% rhenium to the tantalum eliminated twinning at 77 kelvin and facilitated slip deformation at 4.2 kelvin for certain crystal orientations.[19]

Preparation of hafnium-tantalum alloys containing 40% to 50% tantalum, by direct reaction between hafnium carbide and tantalum oxide was studied. Several pelletized samples of different oxygen-to-carbon ratios were sintered in a vacuum induction furnace for 2 hours at 1,650° C and at 2,000° C. After sintering the pellets were heated in an electron beam furnace at from 1 to 2.7 kilowatts of power for a period of 2 to 3 hours. Analysis and hardness values of the hafnium-tantalum alloys established the feasibility of preparing the alloys under vacuum by this method.[20]

The tantalum-hydride system was studied for various concentrations of hydrogen by resistivity measurements of tantalum wires doped with hydrogen. Results indicated the formation of a phase transformation on cooling below 149 kelvin, 156 kelvin, and 189 kelvin for three different ratios of hydrogen to tantalum of 0.25%, 0.40% and 1.4%, respectively.[21]

The discovery of a new mineral, olmsteadite, containing columbium and tantalum was reported. It occurs as deep brown to black prismatic crystals at the Hesnard and Big Chief pegmatites, Black Hills, S.Dak.[22]

The crystal structure of columbium hydride (CbH) was studied for its potential application to fusion-reactor technology. Two beta-phase precipitations of the CbH system were found. These consisted of dendritic crystals at high supersaturations of hydrogen and crystal plates at low supersaturations. The domain configuration of the beta-phase was given as an orthorhombic unit cell and multiple twinning intersecting the a axis and parallel to the b and c axes (100), during beta-growth.[23]

A similar study showed that the morphology of the beta-phase of columbium hydride depended on the cooling rate and on the degree of undercooling. The volume change caused by hydride precipitation resulted in plastic deformation of the matrix. Elastic and plastic adjustment for change in volume had a major effect on the equilibrium of the beta and alpha phases.[24]

A new type of ductile superconducting material was formed by incorporating 10% of columbium in a ductile metal, such as copper containing about 1% tin. The new material was formed into a copper base alloy with a small quantity of superconducting filaments in the matrix. The cost was reported to be not much more than ordinary copper wire.[25]

Several U.S. patents were issued in 1976 for the recovery of columbium and tantalum from low-grade raw materials.[26]

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[19]Shields, J. A., S. H. Goods, R. Gibala, and T. E. Mitchell. Deformation of High-Purity Tantalum Single Crystals at 4.2 K. Mater. Sci. and Eng., v. 20, 1975, pp. 71-81.

[20]Journal of the Less-Common Metals. The Preparation of Hafnium-Tantalum Alloy by Carbide-Oxide Reaction. V. 50, 1976, pp. 245-251.

[21]Verdini, L. A Resistometric Study of the Tantalum-Hydrogen System. J. Less-Common Met., v. 49, September-October 1976, pp. 329-339.

[22]Moore, P. B., T. Araki, A. R. Kampf, and I. M. Steele. Olmsteadite, $K_2Fe_2(2 + (Nb,Ta)_25 + O_4(H_2O)_4(PO_4)_4)$, a New Species, Its Crystal Structure and Relation to Vauxite and Montgomeryite. Am. Mineral., v. 61, Nos. 1-2, 1976, pp. 5-11.

[23]Schober, T., and V. A. Linke. Metallographic Study of the Niobium-Hydrogen System. Part I. Beta-Phase Room Temperature Morphologies. J. Less-Common Met., v. 44, 1976, pp. 63-76.

[24]Birnbaum, H. K., M. L. Grossbeck, and M. Amano. Hydride Precipitation in Nb and Some Properties of NbH. J. Less-Common Met., v. 49, 1976, pp. 357-370.

[25]Industry Week. Emerging Technologies. V. 187, No. 10, Dec. 8, 1975, p. 26.

[26]Meyer, H. (assigned to Herman C. Starck, Berlin). Method for Upgrading the Concentration of Columbium or Tantalum in Tin Slag or Other Ore Smelter Slags or Residues. U.S. Pat. 3,972,710, Aug. 3, 1976.

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Charlot, G. (assigned to Ste. Française d'Electrometallurgie). Extraction of Columbium, Rare Earths, and Thorium From Pyrochlore. U.S. Pat. 3,947,542, Mar. 30, 1976.

Bowerman, P. D. (assigned to Kerr-McGee Chemical Corp.). Extraction of Columbium Values From a Solution Obtained by Leaching With Hydrochloric Acid Ilmenite or Other Ore Containing Titanium, Vanadium, and Columbium. U.S. Pat. 3,975,495, Aug. 17, 1976.

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Brandstatter, H. G. (assigned to Ontario Research Foundation). Recovery of Carbides of Manganese, Chromium, Vanadium, Columbium, Molybdenum, Tungsten or Other Metals From Iron-Bearing Oxide, Hydroxide, or Carbonate Ores Thereof. U.S. Pat. 3,999,981, Dec. 28, 1976.

Copper

By Harold J. Schroeder [1] and George J. Coakley [1]

In 1976 world mine production of copper recovered from the decline of 1975 with a 7% increase to a record high output of 8.2 million tons. The United States continued to lead the world in mine production with 20% of the total, followed by Chile, the U.S.S.R., Canada, Zambia, Zaire, and Poland. Improvement in demand during the first half of the year, concern over disruption of transport systems used by central African producers, and speculative buying of copper contributed to an advance in the

[1]Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient copper statistics

	1972	1973	1974	1975	1976
United States:					
Ore produced ______ thousand short tons__	266,831	289,998	293,443	263,003	283,736
Average yield of copper ________percent__	0.55	0.53	0.49	0.47	0.51
Primary (new) copper produced—					
From domestic ores, as reported by—					
Mines _____________short tons__	1,664,840	1,717,940	1,597,002	1,413,366	1,605,586
Value _____________thousands__	$1,704,796	$2,044,349	$2,468,964	$1,814,763	$2,234,975
Smelters _____________short tons__	1,649,130	1,705,065	1,532,066	1,374,324	1,461,256
Percent of world total____________	22	22	19	18	18
Refineries_____________short tons__	1,680,412	1,698,337	1,420,905	1,286,189	1,422,723
From foreign ores, matte, etc., as reported by refineries _______________do____	192,821	170,151	233,753	157,189	116,585
Total new refined, domestic and foreign _________do____	1,873,233	1,868,488	1,654,658	1,443,378	1,539,308
Secondary copper recovered from old scrap only ____________do____	458,194	486,214	483,432	369,173	419,126
Exports:					
Metallic copper ______________do____	241,600	292,504	246,205	304,712	218,260
Refined _________________do____	182,743	189,396	126,526	172,426	111,887
Imports, general:					
Unmanufactured _____________do____	415,611	420,513	608,602	324,126	534,713
Refined _________________do____	192,379	202,955	313,569	146,805	381,524
Stocks Dec. 31: Producers:					
Refined _________________do____	57,000	37,000	101,000	207,000	190,000
Blister and materials in solution _______________do____	281,000	265,000	324,000	312,000	321,000
Total _________________do____	338,000	302,000	425,000	519,000	511,000
Consumption:					
Refined copper ______________do____	2,238,867	2,437,048	2,194,168	1,534,508	1,991,885
Apparent consumption, primary copper_____________do____	1,901,000	1,902,000	1,778,000	1,312,000	1,826,000
Apparent consumption, primary and old copper (old scrap only) ____________do____	2,359,000	2,388,000	2,261,000	1,681,000	2,242,000
Price: Weighted average, cents per pound________________________	51.2	59.5	77.3	64.2	69.6
World:					
Production:					
Mine ________________short tons__	7,321,950	7,844,901	r8,047,959	r7,671,661	8,212,779
Smelter_________________do____	7,404,601	7,878,480	r8,067,651	r7,792,556	8,163,968
Price: London, average cents per pound________________________	48.53	80.86	93.13	56.08	63.92

rRevised.

price of copper on the London Metal Exchange (LME) from 54 cents per pound for January to 75 cents for July. A slowdown in demand and a buildup in world refined copper stocks to record high levels during the second half of the year resulted in a downtrend in prices to an average 58 cents for December.

In the United States, mine, smelter, and refinery outputs of copper, consumption of copper, and net imports of copper were all substantially larger when compared with 1975, but, except for mine production, were still below 1974 levels. The supply of refined copper from domestic production and net imports exceeded consumption and resulted in a substantial combined increase for producer, consumer, and exchange warehouse stocks. Producer prices in the United States approximated the LME pattern with increases in March, April, and July totaling 11 cents, followed by cuts of 4 cents in October and 5 cents in December to a quotation of 65 cents per pound for refined cathode copper.

Legislation and Government Programs.—The Federal Preparedness Agency (FPA) completed an interagency study of stockpile policy and procedures during 1976 and on October 1 announced new stockpile goals, including a goal of 1,299,000 tons for refined copper. Disposal of nearly 252,000 tons of copper from the stockpile in 1974 had reduced the inventory to only 489 tons which was disposed of by August 1976. Initial purchases against the new goal have not been scheduled. However, 20,261 tons from the previous stockpile that remained unused from transfers to other Government agencies was transferred back into the new stockpile.

The U.S. Department of Commerce amended Schedule A of Defense Materials System Order 4, effective November 1, to revise the base period and the set-aside percentages for copper-controlled materials. The amendment changes the base period from calendar year 1971 to calendar year 1975 and the set-aside percentages from 9% to 7% on unalloyed rod, bar, shapes, and wire; from 4% to 2% on alloyed plate, sheet, strip, and rolls; from 10% to 2% on alloyed rod, bar, shapes, and wire; and on alloyed tube for which no reserve space was previously required, a 10% set-aside was established.

Import duties on copper ores, concentrates, blister, and refined copper remained at 0.8 cent per pound. The duty remained suspended on copper and copper-base scrap through June 1978.

The Generalized System of Tariff Preferences (GSP) was implemented January 1, 1976, in accordance with Title V of the Trade Act of 1974. The system consists of duty-free treatment for a period up to 10 years, on a wide range of designated articles imported directly from any developing country designated as a beneficiary developing country (BDC). All copper items imported from BDC's have been granted GSP status. There are a number of limitations to the program such as the provision that a country does not receive GSP coverage if the imports of a particular article from that country exceed 50% by value or more than $25 million of the particular item during the previous calendar year. This provision is reviewed every year for possible changes.

DOMESTIC PRODUCTION

PRIMARY COPPER

Mine Production.—Domestic mine production of recoverable copper was 1.61 million tons, a 14% increase from 1975. Principal copper producing States were Arizona, with 63.8% of the total, Utah (11.6%), New Mexico (10.7%), Montana (5.7%), Nevada (3.6%), and Michigan (2.7%). These States accounted for 98.1% of total production. In the latter part of the year, output was curtailed at a number of operating properties as an adjustment to a growing imbalance of new supplies to demand.

Open pit mines accounted for 84% of mine output, and underground mines accounted for 16%. The production of copper from dump and in-place leaching, mainly recovered by precipitation with iron, was 126,144 tons or 8% of mine output. Total mine production of copper recovered by leaching methods was 282,501 tons, of which 207,309 tons was precipitated with iron and 75,192 tons was electrowon.

Duval Corp., a subsidiary of Pennzoil Co., operated the Sierrita, the Esperanza, and the Mineral Park copper-molybdenum open pit mines in Arizona and the Copper Canyon open pit copper mine in Nevada. Sales of copper in the form of concentrates and

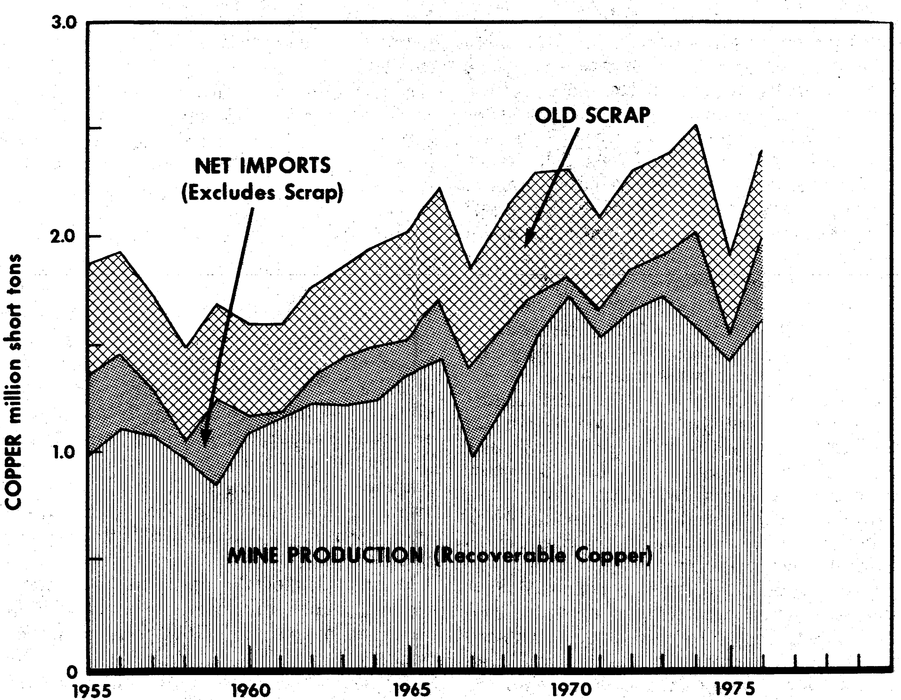

Figure 1.—Sources of copper supply for United States copper consumption.

precipitates from these four operations totaled 100,680 tons compared with 156,608 tons in 1975.

The Anaconda Company produced 91,259 tons of copper at the Berkeley pit at Butte, Mont., compared with the reduced output of 75,030 tons in 1975. Output of copper from the Yerington mine at Weed Heights, Nev., and the Victoria mine near Ely, Nev., totaled 36,920 tons compared with 41,190 tons in 1975. A major underground copper mine, the Carr Fork project in the Bingham district of Utah, was under development with completion scheduled for 1979. The initial rate of production was planned to be 48,000 tons per year with an increase to 65,000 tons 3 years later.

Anamax Mining Co., a joint venture of The Anaconda Company and AMAX Inc., operated the Twin Buttes, Ariz., open pit mine and produced 247,825 tons of copper concentrates from processing sulfide ore and 28,962 tons of electrowon refined copper from processing oxide ores. The 40,000-ton-per-day sulfide mill resumed operation in January after a 10-month shutdown. The 10,000-ton-per-day oxide ore leach-electrowinning plant had its first full year of operation.

Anamax and ASARCO Incorporated entered into a partnership known as the Eisenhower Mining Co. to develop the Palo Verde copper deposit, which is 6 miles from the Twin Buttes operation and between two ASARCO operations. Stripping of overburden from the deposit, which is estimated to contain 125 million tons of ore averaging 0.6% copper, began in the third quarter.

Kennecott Copper Corp. operated mines in Arizona, Nevada, New Mexico, and Utah; these mines produced a combined total of 346,427 tons of copper, a 20% increase from the 1975 output. The Utah Copper Div. accounted for 188,917 tons of the total followed by Chino Mines Div. (New Mexico) with 57,202 tons, the Ray Mines Div. (Arizona) with 88,089 tons, and the Nevada Mines Div. with 12,219 tons. Mining and milling operations were suspended early in 1976 at the Nevada operations because of high operating costs and closure of an associated smelter pending resolution of disagreements on required pollution control facilities. Development work on a potential copper deposit beneath the perimeter of the Utah Copper Div.'s Bingham Canyon open pit mine continued during 1976. A contract was awarded for the erection of surface ancillary facilities which will allow sinking of a shaft during 1977. An environmental impact statement for development of a copper mine near Ladysmith, Wis. was found to be adequate and in compliance with State requirements. Delays anticipated in obtaining permits and meeting other obstacles will probably defer the startup of the project until at least 1980. Plans call for an initial annual production of 11,000 tons of copper in concentrates. Engineering plans progressed during 1976 in anticipation of possible expansion of productive capacity at Chino Mines Div. and Ray Mines Div.

ASARCO operated three copper mines in the vicinity of Tucson, Ariz. The Mission and Silver Bell units, in response to a weak-market situation, were operated on a reduced schedule from mid-1975 until August 1976, when they were restored to normal production rates. Outputs at the two units were 35,200 tons and 22,300 tons of copper in concentrates and precipitates compared with 26,900 tons and 18,300 tons in 1975. The San Xavier mine and leach plant operated at normal levels throughout the year and produced 11,400 tons of copper in precipitates. The Sacaton open pit mine and mill near Casa Grande, Ariz. produced 22,000 tons of copper in concentrates. Development work for the mining of a deeper ore body by underground block-caving methods was suspended in 1976 because of low copper prices and high capital costs, but the project was scheduled for reactivation in the first quarter of 1977.

Mines of the Phelps Dodge Corp. produced a record high 331,000 tons of copper in 1976. Production at the Metcalf mine near Morenci, Ariz., which began operation in 1975, produced 52,700 tons of copper in concentrates. Output in concentrates at Morenci, Ariz.; Ajo, Ariz.; and Tyrone, N. Mex., were 104,500 tons, 50,200 tons, and 87,400 tons, respectively. Leaching of waste dumps and tailings and other miscellaneous sources contributed 36,100 tons of copper. Underground development work continued at Safford, Ariz., toward eventual mining of a deep ore body containing an estimated 400 million tons of ore with an average grade of 0.72% copper. However, no decision was made on when to bring this property into production.

Cities Service Co. operated mines in Arizona and Tennessee that produced 86,600 tons of copper compared with 46,900 tons in 1975. The increased output reflected an achievement during the second full year of operation of the Pinto Valley open pit mine and mill facilities near Miami, Ariz., of an operating rate 6% above the design capacity of 40,000 tons of ore per day. A program to expand production to 50,000 tons per day is planned for completion in 1978. A solvent extraction-electrowinning plant replaced the leach-precipitation plant at the Miami mine in midyear. Startup of the underground Miami-East mine, originally scheduled for 1976, was postponed because of escalated costs and adverse market conditions.

The White Pine, Mich., operations of White Pine Copper Co., in response to continued depressed business conditions in the copper industry and as part of a plan to conserve cash and reduce expenditures, curtailed mine operations during the year to an average 43.2% of design capacity. Selective mining resulted in an average 1.38% copper ore grade compared with 1.01% in 1975, and the mill achieved a recovery rate of 87.8% compared with 85.6% in 1975. The smelter operated with only one of the two reverberatory furnaces and produced 45,912 tons of refined copper.

Magma Copper Co. operated two underground copper mines in Arizona with a combined output of 145,000 tons of copper compared with 139,000 tons in 1975. The San Manuel mine was operated at a curtailed level during both 1975 and 1976. At the smaller Superior mine, production was maintained at full capacity.

Inspiration Consolidated Copper Co. operated the Thornton, Live Oak, Red Hill, and Joe Bush open pit copper mines in the vicinity of Inspiration, Ariz.; 8.8 million tons of waste and 4.6 million tons of ore were mined for a combined 13.4 million tons of material handled. Approximately 4.4 million tons of the ore was treated in the concentrator with part of the concentrator feed first processed in leaching tanks to recover acid-soluble copper. The combined production from in-plant processed ore in the form of concentrates, precipitates, and electrowon cathodes was 25,586 tons of copper. Waste dump leaching of mined material, too low in copper content for in-plant treatment, yielded an additional 10,339 tons of copper. At the Ox Hide mine, 2.2 million tons of ore was mined for heap leaching dumps and 3,968 tons of copper was recovered in the form of precipitates. At the Christmas open pit mine, southeast of Miami, Ariz., output was 6,971 tons from processing 1.6 million tons of ore and removal of 4.8 million tons of waste. Total mine production from all operating mines was 48,864 tons of copper compared with 55,815 tons in 1975.

The Cyprus Pima Mining Co. operated

the open pit Pima mine near Tucson, Ariz., milling 19.6 million tons of ore averaging 0.47% copper. Proven ore reserve at yearend was estimated to be sufficient to sustain the operation for about 8 years at the 1976 production rate. Cyprus Bagdad Copper Co. at its Bagdad, Ariz., property mined 2.0 million tons of sulfide ore averaging 0.60% copper. In addition 7,600 tons of cathode copper produced by a leach-electrowinning process were sold. Progress continued on a major mine-mill expansion program designed to handle 40,000 tons of ore per day with initial production using the new facilities scheduled for September 1977. Ore reserves at yearend were nearly 300 million tons of proven ore averaging 0.49% copper. Exploratory drilling during the year indicated the probability of additional reserves. The Cyprus Bruce Copper and Zinc Co. operated its underground copper-zinc mine near Bagdad, Ariz., and mined 90,300 tons of ore grading 3.5% copper and 13.0% zinc. Ore reserves at yearend were 127,600 minable tons, sufficient for only a little more than 1 year's operation. The Cyprus Johnson Copper Co. mined 1.3 million tons of oxide-copper ore from a deposit near Johnson, Ariz., in the first full year of operation. The ore contained 0.418% acid-soluble copper and was treated by a leach-electrowinnning process to produce refined copper cathodes. Reserves of oxide-copper ore with 0.50% acid-soluble copper were estimated to be sufficient for at least 8 years of operation at the 1976 rate of production.

Ranchers Exploration and Development Corp. produced in excess of 8,000 tons of copper cathodes-a record high-by a leaching-solvent extraction-electrowinning process at its Bluebird mine near Miami, Ariz. The in situ leaching operation at the Old Reliable deposit near San Manuel, Ariz., and the leaching operation at the Big Mike mine near Winnemucca, Nev., were on standby throughout 1976, awaiting more favorable marketing conditions.

Hecla Mining Co. in a joint venture with El Paso Natural Gas Co. completed mine development and plant construction at the Lakeshore copper mine south of Casa Grande, Ariz., and placed the project in operational status on April 1. The plant was designed to mill 11,000 tons per day of sulfide ore with the concentrate treated by roasting, leaching, and electrowinning to produce 30,000 tons per year of refined cathode copper. The roasting operation will produce 200 tons per day of sulfuric acid for use in a 6,000-ton-per-day vat leaching plant to process oxide ore. The leach plant design capacity was 35,000 tons of copper per year in the form of precipitate copper. Mine output for 1976 was 8,215 tons as refined copper and 11,405 tons as copper in precipitates. An additional 8,758 tons of refined copper was produced from processing purchased concentrates.

UV Industries, Inc., operated the Continental mine near Bayard, N.Mex., mining 668,435 tons of ore with an average copper assay of 1.66% from underground operations and 1,650,352 tons of ore with an average copper assay of 0.83% from open pit operations. Concentrates produced from milling the ore totaled 88,862 tons with an average copper content of 26%. Estimated reserves at yearend were 18.8 million tons averaging 0.88% copper suitable for open pit mining and 18.9 million tons averaging 1.96% copper suitable for underground mining.

Smelter Production.—Output of copper at primary smelters in the United States was 1.59 million tons, a 6% increase from production of the preceding year.

ASARCO completed and placed in operation a new baghouse to filter gases from the metallic arsenic plant at its Tacoma, Wash., smelter. Major repairs and modifications were made to the sulfuric acid plant originally built in 1971 at the Hayden, Ariz., smelter. The acid plant, together with the air monitoring system installed in 1975, enabled the plant to qualify for a conditional operating permit from State authorities. At El Paso, Tex., work began on the first phase of a comprehensive modernization and quality control program designed to bring both the copper and lead smelters into compliance with governmental standards. The initial work will improve fugitive emissions at ground level by enclosing completely and ventilating the building housing the converter furnaces.

Kennecott closed its McGill, Nev., smelter on August 1 as a result of a rejection by the Environmental Protection Agency (EPA) of the company's plans for meeting emission standards. A court ruling late in the year supported the company's position and plans were to reopen the smelter early in 1977. At the Garfield, Utah, smelter, work was well advanced on an extensive construction project for improved environmental controls to be partly phased into operation in 1977. Included in the project will be the replacement of existing reverberatory furnaces and converters with a continuous smelting-converting unit and also construction of an additional sulfuric acid plant.

Phelps Dodge began operation of a new copper smelter in Hidalgo County, N. Mex. Cost of the smelter project, including a townsite and a 36-mile industrial railroad, was placed at $268 million. It is the first smelter in the United States to utilize the flash smelting process. Initially the facility has the capacity to treat about 1,400 tons of concentrates daily, equivalent to about 100,000 tons of anode copper annually. In accord with an agreement to smelt concentrates from the Bagdad, Ariz., operation of Cyprus Mines Corp., beginning in 1978, additional construction to increase the smelter capacity was underway.

San Manual smelter operations of Magma Copper Co. were adversely affected during the fourth quarter by an unusually high number of intermittent curtailments required for air pollution control during atmospheric inversions. The intermittent cooling and reheating resulted in deterioration in the physical condition of the furnaces and consequently lower efficiency and throughput. Operating practices were being developed to reduce the frequency and severity of such curtailments.

Refined Production.—In 1976 production of refined copper from primary materials increased 7% to 1.54 million tons, a partial recovery from the low output of 1975. Refined copper produced from scrap was 375,150 tons compared with 344,500 tons in 1975. Total production of refined copper in the United States was 1.91 million tons derived 80% from primary and 20% from scrap sources.

A new refinery of ASARCO at Amarillo, Tex., rated at 420,000 tons of annual copper capacity was operated for the first full year. This refinery replaced the company's Baltimore refinery, closed in 1975 and the Perth Amboy, N. J., refinery closed in 1976.

Kennecott completed an expansion project at the Ray Mines Div. (Arizona) to increase the silicate copper leaching - electrowinning plant by 40%. Overall performance of the new plant exceeded design projections.

As described in detail under mine production projects, associated copper electrowinning units were placed in operation during the year by Hecla Mining Co. and Cities Service Co.

Copper Sulfate.—Copper sulfate was produced from electrolytic tankhouse solutions, blister copper, and secondary metal by companies with plants located as follows:

Company	Plant location
The Anaconda Company	Great Falls, Mont.
Chevron Chemical Co	Richmond, Calif.
Cities Service Co	Copperhill, Tenn.
Phelps Dodge Refining Corp	Laurel Hill, N.Y., El Paso, Tex.
Van Waters & Rogers Inc	Wallace, Idaho.

Copper sulfate production decreased to 32,122 tons, and was the smallest quantity since 1935. Production exceeded shipments plus consumption by producing companies by 1,691 tons and ending stocks of 8,557 tons were the highest yearend levels since 1970. Of the total 30,431 tons shipped, producers reports indicated that 13,479 tons was for agricultural uses, 16,710 tons was for industrial uses, and 242 tons was for other uses.

Byproduct Sulfuric Acid.—Sulfuric acid was produced at 14 copper smelters from the sulfur contained in offgases, and output increased for the ninth consecutive year from 1,784,700 tons to a record 2,281,600 tons on a 100% acid basis. New sulfuric acid plants were brought into production at the Hidalgo County, N. Mex., smelter and the new Casa Grande, Ariz., roasting-electrowinning plant.

SECONDARY COPPER AND BRASS

Domestic recovery of copper in all forms from all classes of purchased scrap totaled 1.15 million tons in 1976, an 18% increase from the 1975 total. Recovery from copper-base scrap advanced from 0.95 million tons to 1.11 million tons. Brass mills accounted for 47% of the recovered copper, primary producers for 26%, and secondary smelters for 22%. The remaining 5% was reclaimed at chemical plants, foundries, and manufacturers.

Consumption of purchased copper-base scrap in 1976 was 1.51 million tons consisting of 62% new scrap and 38% old scrap. Of the major categories of copper and copper-alloy products derived from scrap, the output of unalloyed copper, brass mill products, and brass and bronze ingots were 390,700 tons, 649,700 tons, and 228,700 tons.

CONSUMPTION

Consumption of refined copper increased substantially during the year from that of 1975, with peak consumption levels reached during the second quarter of 1976. Total consumption for the year was 2.0 million tons, an increase of 30% from 1975 but 9% below 1974. Wire mills accounted for 68% of refined copper consumption, brass mills accounted for 29%, and all other categories accounted for the remaining 3%.

Apparent withdrawals of primary refined copper on domestic account was 1.82 million tons compared with 1.31 million tons in 1975.

STOCKS

Stocks of refined copper at primary producers were 207,000 tons at the start of the year, increased to 216,500 tons by the end of April, decreased to 164,200 tons by August, then were built up to 190,000 tons by yearend. At wire rod mills, brass mills, other refined copper consumers, and secondary smelters yearend refined copper stocks of 157,000 tons were slightly higher than at the start of the year. Refined copper stocks reported by the New York Commodity Exchange (COMEX) rose from 100,000 to 201,000 tons.

PRICES

Prices on the LME increased from a monthly average of 54.1 cents per pound for January to 74.7 cents in July, and then declined to 58.4 cents in December. The average LME price for 1976 was 63.9 cents compared with 56.1 cents in 1975.

Producer prices in the United States approximated the LME pattern with increases of 3 cents in March, 4 cents in April, and 4 cents in July, followed by cuts of 4 cents in October and 5 cents in December to a quotation of 65 cents per pound for refined cathode copper. Electrolytic wirebar quotations were 0.625 cent above the quotations for cathode copper. Average quoted prices for electrolytic wirebar copper was 69.6 cents compared with 64.2 cents for 1975.

FOREIGN TRADE

Net imports of copper were a relatively large supply component in 1976 as imports of unmanufactured copper, excluding alloyed copper scrap, were 534,700 tons compared with 324,100 tons in 1975, while exports decreased from 233,900 to 172,000 tons. The largest trade category, refined copper, increased from 146,800 tons to 381,500 tons for imports, while exports declined from 172,400 tons to 111,900 tons. Canada supplied 29% of the total imports, followed by Zambia with 24% and Chile with 19%. Imports of blister copper were 44,500 tons compared with 89,000 tons in 1975. The other import categories of ore, concentrates, matte, and unalloyed copper scrap totaled 108,700 tons and the other export categories of ore, concentrates, matte, blister, unalloyed scrap, and ash and residues totaled 60,200 tons.

Exports of alloyed copper scrap, in gross weight, were 76,700 tons compared with 99,200 tons in 1975. Imports of alloyed copper scrap were 14,600 tons, gross weight, or 9,600 tons copper content.

WORLD REVIEW

World mine production of copper increased 7% to 8.21 million tons in 1976. The United States continued to lead the world in mine production with 20% of the total, followed by Chile 13%, the U.S.S.R. 11%, Canada 10%, Zambia 10%, Zaire 6%, Poland 4%, Philippines 3%, Australia 3%, Peru 3%, the Republic of South Africa 3%, and Papua New Guinea 2%.

World stocks of refined copper, as reported by the World Bureau of Metal Statistics, continued to reflect oversupply conditions. Stocks grew to 1,843,000 tons by yearend, representing an increase of 9% over 1975. The reported stocks included producer, consumer, and merchant inventories of 623,000 tons (including 201,000 tons in COMEX warehouses) of refined copper in the United States, 283,000 tons in Japan, 199,000 tons combined between France, West Germany, and the United Kingdom, plus 665,000 tons held in LME warehouses. The total reported world stock level, valued at $2.4 billion, represented the equivalent of a 3.1-month demand based on the average monthly world market economy consumption of refined copper of 590,000 tons in 1976.

The major copper producing and consuming countries held three meetings in 1976 under the auspices of the United Nations Conference on Trade and Development (UNCTAD) to examine the causes of market instability and to consider possible ways to correct the problem. At the initial meeting in March, set up on an ad hoc basis at the request of the Conseil Intergouvernemental des Pays Exportateurs de Cuivre (CIPEC), general support was given toward establishment of a permanent consultative body for copper to provide the means for further work on the problem.

The direction of the subsequent copper meetings was strongly affected by Resolution 93 IV, An Integrated Program for Commodities, issued at the UNCTAD IV meeting between the developed and developing countries at Nairobi, Kenya, in May 1976. Resolution 93 IV called for a cycle of preparatory meetings on 18 commodities, including copper, designed to explore possible solutions to the problems of their markets. Among items to be considered were the possible formation of commodity agreements involving the use of buffer stocks and the formation of an international Common Fund to finance commodity agreement operations.

The September 1976 meeting in Geneva then became the first UNCTAD preparatory meeting on copper. It was decided to set up an Intergovernmental Expert Group on Copper (IEGC) composed of representatives from countries with a significant interest in production, consumption, or trade in copper. The IEGC mandate called for the collection and examination of basic data on the industry and for consideration of possible solutions to problems of the industry, including, among others, interim base-price contract measures and buffer stock agreements. The first formal meeting of the IEGC, held in Geneva in November, was mainly organizational with final agreement made on a list of studies to be carried out by individual members prior to a 2-week working meeting in February 1977.

In general, the three 1976 meetings delineated the complexities of the world copper market and highlighted the difficulties involved in reaching a workable solution to its problems.

At the ninth annual Ministerial Conference of CIPEC held at Santiago, Chile, in December 1976, continued concern was expressed about the gravity of the world economic and monetary climate as it affected current world copper market prices and the future of new copper developments.

The Ministers voted to continue support of the UNCTAD producer-consumer dialogue seeking a solution to these problems. An extraordinary session was to be called in early 1977 to discuss possible interim measures for stabilizing copper prices while awaiting agreement on other long term solutions. In other policy action, CIPEC announced that it would increase support to existing national copper development centers. Support would include granting of interim financial assistance to help the centers defend markets and develop new copper uses.

Australia.—Mine production decreased 1% to 239,680 tons, smelter production dropped 6% to 186,840 tons, and refinery output decreased 3% to 177,190 tons from 1975. Mine and smelter production was down over 13% each from peak output levels of 1974. In response to requests from the depressed domestic copper industry, the Australian Government approved two major actions in 1976. The Industries Assistance Commission recommendation on assistance to the copper ore and concentrate industry was accepted, whereby, the Government will guarantee repayment of principal and interest on commercial loans made by qualifying copper companies. These guarantees will apply to loans of companies which are judged viable under normal conditions but are taking a cash loss on current production. The size of the loan is designed to bring the companies to a cash break-even position from January 1, 1976, until June 30, 1977. In August 1976, under other governmental action, the Price Justification Tribunal announced it will not impose an artificial ceiling price on copper sold in Australia by the market leader, Mount Isa Mines Ltd. (MIM).

MIM Holdings Ltd., operated its copper-lead-zinc-silver mine and copper smelter at Mount Isa and a copper refinery at Townsville, Queensland. For the fiscal year ending June 30, 1976, MIM treated 4.77 million tons of copper ore grading 3.4% copper compared with 5.46 million tons grading 3.2% copper in 1975. Blister copper output decreased 7% to 164,926 tons while production of refined copper dropped 9% to 160,700 tons. Remaining copper ore reserves were estimated at 150 million tons of 3.21% copper.

Mount Lyell Mining & Railway Co., Ltd., a subsidiary of Consolidated Gold Fields Ltd., for the year ended June 30, 1976, decreased production 18% to 22,560 tons of copper in concentrate from 2.44 million tons of ore grading 1.09% copper mined and milled at its Queenstown, Tasmania, operation. In December, in response to depressed copper prices, Mount Lyell announced plans to reduce production from 24,250 tons per year to 16,500 tons. Reserves in all ore zones were estimated at 30 million tons of proven ore grading 1.46% copper and 11.1 million tons of probable ore grading 1.41% copper.

Gunpowder Copper Ltd., owned 48% by Consolidated Gold Fields and located 80 miles north of Mt. Isa, operated at a loss for the year ending June 30, 1976, while increasing production 14% to 9,150 tons of contained copper. A development program will double capacity to 600,000 tons of ore annually by late 1978. Reserves at Gunpowder's Mammoth mine stand at 8.8 million tons grading 3% copper.

Cobar Mines Pty., Ltd., fully owned by BH South Ltd., in the year ending June 30, 1976, treated 655,240 tons of ore averaging 1.9% copper producing 9,420 tons of copper contained in 36,930 tons of concentrates. Byproduct zinc and lead were also recovered. Production for the foreseeable future will be concentrated in more highly productive open stopes at a rate of 660,000 tons per year. Advance underground development work was suspended.

Kanmantoo Mines Ltd., in Kanmantoo, South Australia, also held by BH South Ltd., decreased production for the fiscal year ending June 30, 1976, 5% to 7,098 tons of copper contained in 30,180 tons of concentrates recovered from 916,700 tons of copper ore milled. An additional 800 tons of copper contained in concentrates was obtained from treatment of stockpiled oxide ore. Development work on an adjacent underground ore body was almost completed when the entire operation was placed on a care and maintenance basis on June 30, 1976. Remaining reserves have been estimated at 8 million to 13 million tons of 1% copper.

Peko-Wallsend Ltd., operated the copper-gold mine at Mount Morgan, Queensland, and the Tennant Creek copper-gold-bismuth mines in the Northern Territory. At the Tennant Creek operations, the suspension of all copper mining and smelting activities continued throughout the year. During

1975-76 fiscal year, Mount Morgan produced 9,100 tons of contained copper in 1 million tons of ore treated. Remaining reserves were estimated at 330,000 tons grading 0.90% copper. The smelter produced 10,960 tons of blister copper, up 15% over 1975.

Botswana.—Bamangwato Concessions, Ltd. (BCL), operated the Pikwe open pit and underground nickel-copper mine and flash smelter. Development work on the Selebi underground ore body continued with startup planned for January 1980. Production at Selebi must be phased in to offset the depletion of the open pit by July 1980. BCL overcame its prolonged startup problems and by yearend was operating at a near capacity rate of 1.3 million tons of ore and 46,000 tons of matte annually. Proven and probable ore reserves as of December 31, 1976, were estimated at 48.3 million tons grading 1.10% nickel and 1.20% copper.

During the year, ore milled increased 81% to 2,292,600 tons grading 1.07% nickel and 0.86% copper compared with 1,267,500 tons grading 1.15% nickel and 0.94% copper in 1975. Production of a 75% to 80% copper-nickel matte nearly doubled from 18,200 to 35,830 tons during the year. Matte production is shipped to AMAX's Port Nickel, La., plant for refining. Port Nickel received 14,224 tons of imported matte from Botswana in 1976.

Canada.—Mine production increased 2% in 1976 to 823,570 tons of recoverable copper. Smelter output decreased 2% to 538,580 tons, and refinery production decreased 4% to 562,750 tons of copper. Mine production increased in nearly all Provinces in 1976 except for Manitoba, New Brunswick, and Newfoundland. British Columbia was the leading copper-producing Province with 36% of the total, followed by Ontario 35%, Quebec 16%, Manitoba 8%, and the remaining Provinces 5%.

Reviewing the activities of the Canadian copper industry for the year by Province, in British Columbia, Afton Mines Ltd., controlled 54% by Teck Corp. Ltd., began construction in May 1976 on a new $80 million mine, mill, and smelter complex. With a capacity of 30,000 tons per year of blister copper, construction is scheduled for completion in late 1977.

Bethlehem Copper Corp. Ltd. milled 7.5 million tons of ore grading 0.44% copper from open pit mines in the Highland Valley, and produced a 36.74% concentrate containing 27,560 tons of copper compared with 27,300 tons of copper in 1975. Reserves at the operating Iona and Jersey mines total 44.9 million tons of 0.46% copper. Reserves at the Huestis mine were exhausted by yearend. A stripping program to remove 25 million tons of overburden to prepare the Jersey extension reserves for mining is scheduled for completion in 1977. At 1976 production rates, reserves were sufficient to provide mill feed through 1982. Bethlehem is currently investigating the feasibility of developing 130 million tons grading 0.51% copper and 0.027% molybdenum of the 286-million-ton J-A ore body by underground block-caving methods. Ore would be transported by an 8,000-foot-long conveyor belt from the mine to the existing 21,000-ton-per-day capacity Bethlehem mill for beneficiation.

The Granduc Operating division of Newmont Mines Ltd. located north of Stewart, British Columbia, operating at 60% of capacity, produced 17,300 tons of copper in concentrate from 1.45 million tons of ore grading 1.26% copper. While producing at about a break-even cash level, Granduc resumed underground development work, which will be needed to make more ore available for mining in 1978. Reserves at yearend were 18 million tons of 1.68% copper.

Lornex Mining Corp. Ltd., controlled by the Rio Tinto-Zinc Corp., Ltd., operated an open pit copper-molybdenum mine in the Highland Valley and produced 72,857 tons of copper up 36% from 1975 and 1,885 tons of molybdenum in concentrate from 17 million tons of ore milled.

The Bell Copper Div. of Noranda Mines Ltd., in Granisle, British Columbia, affected by a 29-week-long strike, mined only 2.1 million tons of ore grading 0.49% copper in 1976. Concentrate output of 28,310 tons contained 7,300 tons of copper, down 60% from 1975.

Brenda Mines Ltd. (50.9% Noranda), located in Peachland, British Columbia, operating one of the lowest grade porphyry copper-molybdenum mines in the world, produced a record 11.2 million tons of ore averaging 0.167% copper and 0.045% molybdenum yielding 16,100 tons of copper in concentrates. The record production was attributed to the successful use of computer-controlled grinding circuits. During the year, new contracts with Japanese and Korean smelters were negotiated. Yearend reserves were 118 million tons of 0.171% copper and 0.043% molybdenum.

Placer Development Ltd. (33% Noranda) operated the Craigmont mine in Merritt, British Columbia, and the Gibralter mine in McLeese Lake, British Columbia, during the year. The Gibralter mine, closed by a strike for 19 weeks, milled 8.5 million tons of ore grading 0.45% copper. Production of copper in concentrates from the Granite Lake pit was reduced 24% to 31,852 tons. Production from the Pollyanna pit was scheduled to begin in late 1977. Reserves decreased to 300 million tons, with an average grade of 0.36% copper. At Craigmont 1.95 million tons of ore grading 1.35% copper was milled. The 88,200 tons of concentrates produced contained 25,283 tons of copper, a decrease of 6% from 1975. Ore reserves of 5.7 million tons of 1.85% copper are sufficient to maintain operations at the 1976 level for 2 to 3 years.

Similkameen Mining Co. Ltd., a subsidiary of Newmont Mining Corp., operated its open pit mine near Princeton, British Columbia, at an expanded concentrator capacity of 22,000 tons of ore per day. Output for the year increased 56% to 25,500 tons of copper in concentrate from milling 7 million tons of 0.42% copper ore. Ore reserves at yearend were estimated at 54 million tons averaging 0.53% copper.

Utah International Inc., shipped concentrates containing 50,000 tons of copper, down 14% from 1975, and 43,000 ounces of gold, down 31%, from its Island Copper mine on the northern end of Vancouver Island in British Columbia. Decreases were attributed to lower mine ore grades and mill recovery rates.

Granby Mining Corp. operated the Granisle open pit mine near Babine Lake. Granisle treated 4.3 million tons of 0.42% copper ore compared with 4.9 million tons of 0.46% ore the previous year. Production of recoverable copper in concentrates decreased 20% to 15,336 tons from 1975. The decrease was attributed to a 24-day-vacation shutdown and to the harder, lower grade ore treated.

In Manitoba, the newly formed Canadian Metals Div. of Hudson Bay Mining & Smelting Co. Ltd. operated six of nine copper and zinc mines full time and one copper smelter in the Flin Flon-Snow Lake area. Approximately 1.56 million tons of ore with an average grade of 2.3% copper and 2.75% zinc were mined and milled to produce 192,541 tons of a 17.02% concentrate containing 32,770 tons of copper, equal to 1975 output. The copper smelter produced 62,050 tons of anode copper from feed supplied 49% from Hudson Bay mines, and 51% from purchased concentrates. The Flin Flon production, representing 48% of total mine production, was chiefly from pillars and remnants. The Dickstone mine remained closed, Schist Lake was depleted in March, and White Lake ceased production in August to allow for further development work. Construction and development work at the new Centennial and Westarm mines was nearly complete, with production start-up scheduled for mid-to-late 1977. Total ore reserves at yearend were about 17.5 million tons grading 2.66% copper, 2.9% zinc, 0.035 ounce of gold per ton and 0.55 ounce of silver per ton. Reserves are based on 17% mine dilution and 91% recovery.

Sheritt Gordon Mines Ltd. operated the Fox, Lynn Lake, and Ruttan Lake mines in Manitoba with a combined output of 37,920 tons of copper in concentrates compared with 44,350 tons in 1975. Copper production was down 9% to 25,030 tons at the Ruttan open pit mine, with 2.66 million tons of ore averaging 1.08% copper and 2.14% zinc milled. At Ruttan preparations were being made to move to an underground mining operation by 1979. At the Fox underground mine, 832,000 tons of ore averaging 1.56% copper and 1.68% zinc were milled with production of copper in concentrates decreasing 23% to 12,116 tons. The Lynn Lake nickel-copper mine was closed in June 1976 for economic reasons. Remaining ore reserves at the Ruttan and Fox mines consisted of 39.9 million undiluted tons grading 1.77% copper and 1.41% zinc. Open pit ore comprised 20% of the total reserves.

The Ontario-based Falconbridge Nickel Mines Ltd. delivered 62,550 tons of copper from five nickel-copper mines in Sudbury, Ontario, and Manibridge, Manitoba, and from seven copper-zinc, copper, and iron-copper mines in Lake Dufault and Opemiska, Quebec, Sturgeon Lake, Ontario, and Tasu Harbor, British Columbia. Concentrates from the nickel-copper operations were processed at the company smelter in

Sudbury and from the other copper-zinc operations at the Noranda Mines Ltd. smelter at Noranda. Deliveries of copper from the integrated nickel operations decreased 16% to 17,040 tons. Sudbury operations remained at a reduced level as four mines, one mill, and one of two blast furnaces remained closed throughout 1976. The company resumed both the development of the 5,000-foot deep Fraser No. 1 shaft at Sudbury and the construction of the $95 million Sudbury Smelter Environmental Improvement Program. Expansion of the Strathcona mill to 8,500 tons of ore per day was also completed. Ore reserves at yearend at Sudbury were 83.4 million tons averaging 1.46% nickel and 0.68% copper. Ore reserves at Manibridge, Manitoba were nearly exhausted and the mine was to close in early 1977.

Deliveries of copper from Falconbridge Copper Ltd. increased 7% to 41,470 tons including 7,140 tons from the new Sturgeon Lake zinc-copper mine.

INCO Ltd., formerly International Nickel Co. of Canada Ltd., mined 19.8 million tons of ore with an average grade of 1.41% nickel and 0.97% copper from 12 mines in Ontario and 3 mines in Manitoba in 1976, compared with 21.2 million tons of ore with an average grade of 1.40% nickel and 0.92% copper in 1975. Deliveries of copper metal from the Copper Cliff refinery increased 6% to 177,995 tons. At yearend, INCO estimated that proven ore reserves in Canada were 412 million tons, containing 1.65% nickel and 1.07% copper. In April, production at the Victoria mine was resumed following a yearlong redevelopment program. The small Kirkwood ore body was depleted by March. Development work at Sudbury on the Clarabelle open pit extension and on the new Levack East mine continued during the year with production startup scheduled for 1978 and 1983, respectively.

At Mattagami Lake Mines Ltd., Mattabi zinc-copper mine in northwestern Ontario, the concentrator treated 1.07 million tons of ore grading 1.23% copper yielding 10,900 tons of contained copper in concentrate. Measured reserves were 9.6 million tons of 7.1% zinc, 0.58% copper, 0.95 ounce of silver per ton, and 0.015 ounce of gold per ton. Development work on Mattagami's new underground mine at Lyon Lake, in the Sturgeon Lake area, continued with initial production of 1,000 tons per day of ore scheduled to begin in 1978. Reserves at the Lyon Lake deposit were 4 million tons of 6.66% zinc, 1.15% copper, 0.63% lead, 3.39 ounces of silver per ton, and 0.010 ounce of gold per ton.

The Geco Div. of Noranda Mines Ltd., in Manitouwadge, Ontario, produced 1.7 million tons of ore grading 1.69% copper, 2.55% zinc, and 1.29 ounces of silver per ton. Concentrates contained 26,300 tons of copper, a decrease of 4%. Reserves at yearend were 27.5 million tons grading 1.87% copper, 3.59% zinc, and 1.49 ounces of silver per ton.

Texasgulf Canada Ltd. operated the Kidd Creek mine near Timmins, Ontario, and milled 3.57 million tons of ore in 1976, down 2% from 1975. Mill feed from the open pit diminished to 43% of the total, with operations expected to be fully underground by 1977. The mill yielded 234,700 tons of copper concentrates, down 2% from 1975. In 1974 and 1975 average concentrate grade was 23.65% copper. At the end of 1976, measured and indicated reserves above the 2,800-foot level were estimated at 85 million tons containing 2.73% copper, 6.08% zinc, 2.30 ounces of silver per ton, and 0.22% lead. In addition, good copper mineralization occurs to at least 5,000 feet. Construction on a $350 million project to increase the mine production rate from 3.6 to 5.0 million tons per year and to build a 100,000-ton-per-year smelter-refinery complex continued during the year. About 10% of the work was complete on the surface metallurgical plants. Startup is scheduled for late 1979.

Union Minière Canada Ltd., on August 24, 1976, started its new Thierry copper mine and mill at Pickle Lake, Ontario. By yearend output was at a rate of 3,500 tons per day. In total, the concentrator treated 254,200 tons of lower grade 1.17% copper ore from the poor upper section of the pit, yielding 10,727 tons of concentrates grading 24.93% copper. Proven reserves amounted to 15 million tons averaging 1.63% copper and exploration work in progress indicated further potential.

In Quebec, Campbell Chibougamau Mines Ltd. finally negotiated a successful new labor contract on August 31, 1976. Production for the year from the Cedar Bay and Henderson mines was 530 tons of copper compared with an annual capacity of over 15,000 tons. Reserves remaining in the Chibougamau area mines totaled 10 million tons grading 1.66% copper and 0.043 ounce of gold per ton.

The Lake Dufault Div. of Falconbridge Copper Ltd., in 1976, produced 14,777 tons of copper in concentrate, up 13% over that of 1975. Underground development and exploration work on the Corbet mine continued during the year. Reserves at yearend were 1.41 million tons of ore grading 3.75% copper and 4.80% zinc. The Opemiska Div. milled 1 million tons of 2.1% copper in 1976 to produce 20,025 tons of copper in concentrate. Remaining reserves for the Springer, Perry, and Cooke mines consist of 14.5 million tons of 2.37% copper. Development of the Cooke mine continued with production startup scheduled for the third quarter of 1977.

Madeleine Mines, operated by McIntyre Mines Ltd. near Ste. Anne des Monts, Quebec, milled 814,000 tons of 1.07% copper yielding 8,147 tons. On October 28 the company suspended operations and placed the mine on a care and maintenance basis.

Noranda Mines Ltd. had a full or partial interest in the treatment of 44 million tons of ore containing 183,100 tons of contained copper from 16 copper and zinc-copper mines in Quebec, British Columbia, Ontario, and New Brunswick. The company's two copper smelters at Noranda, Quebec, and Gaspé Copper in Murdochville, Quebec, treated 710,900 tons of concentrates from Noranda operations and 890,800 tons of custom material from other Canadian copper mines and from overseas. The 1.6 million tons of total material treated yielded 302,600 tons of copper contained in anodes for a decrease of 1% from 1975. The Noranda smelter accounted for 76% and Gaspé accounted for 24% of anode production. Canadian Copper Refineries (CCR) in Montreal East, Quebec, operated by Noranda, was the world's largest copper refinery with an annual capacity of 480,000 tons. In 1976, refinery production decreased 2% to 387,000 tons of copper. CCR processes the output of the Noranda smelters, the Flin Flon smelter of Hudson Bay Mining & Smelting Co. Ltd., and from imported and some secondary sources. After 50 years of operation, Noranda's Horne ore body in Noranda, Quebec, was exhausted in mid-1976, having produced 59 million tons of ore containing 1.3 million tons of copper, 10 million troy ounces of gold, and 22.3 million troy ounces of silver during its lifetime. The Horne Div.'s New Insco mine with reserves of 811,000 tons of 2.8% copper, 0.02 troy ounce per ton of gold, and 1 troy ounce per ton of silver was developed for production during the year.

Gaspé Copper Mines Ltd. (Noranda) milled 1.57 million tons of 1.20% copper ore from the Needle Mountain mine and 10.7 million tons of 0.43% copper ore from Copper Mountain mine yielding approximately 48,200 tons of copper contained in concentrates. Reserves at the two mines were 28 million tons of 1.32% copper, of which 51% is in pillars, and 193 million tons of 0.38% sulfide copper plus 30 million tons of 0.44% oxide copper.

Mattagami Lake Mines Ltd. (43% Noranda) treated, at the Mattagami Lake mine, 1.23 million tons of ore averaging 7.3% zinc and 0.55% copper. Copper contained in concentrates decreased 17% to 4,970 tons. Remaining undiluted ore reserves totaled 9.6 million tons grading 7.1% zinc, 0.58% copper, 0.95 troy ounce of silver per ton, and 0.015 troy ounce of gold per ton.

In the Yukon Territory, Whitehorse Copper Mines Ltd., owned in part by Hudson Bay and Anglo American Corp. of Canada Ltd., mined and milled 800,836 tons of 1.51% copper ore and produced 29,693 tons of concentrate containing an estimated 10,690 tons of copper. Production increased about 7% despite a 70-day strike during the year.

Chile.—In attaining it's highest mine production on record, Chile increased production 21% over that of 1975 to 1,108,000 tons of copper. Production by Corporacion Nacional del Cobre Chile (Codelco-Chile) from the large mines was as follows: Chuquicamata, 491,100 tons compared with 335,800 tons in 1975; El Teniente, 288,500 tons compared with 257,900 tons; El Salvador, 91,200 tons compared with 89,600 tons; and Andina, 62,700 tons compared with 68,800 tons. Mine production exceeded reported capacity at Chuquicamata and suggests that Codelco-Chile was mining a higher grade of copper ore than average during the year. The average grade of proven reserves at Chuquicamata is 1.38% copper.

In the medium and small mine production area, Mantos Blancos increased output by 3% to 33,200 tons, Empresa Nacional de Minera (ENAMI) decreased output 4% to

81,900 tons, and Disputada raised production 10% to 39,400 tons of copper.

Minera Sagasca, S.A., controlled 59% by Continental Copper & Steel Industries, Inc., operated at 50% of capacity for the year and produced 11,400 tons of cement copper. The company, despite a $4 million partial write down of investment, continued a $3.6 million improvement project to increase recovery efficiencies and increase production to 80% of capacity by mid-1977.

Production of blister copper at Chile's six smelters increased 18% over 1975 to 943,900 tons. Electrolytic and fire refined copper output also increased 18% to 696,700 tons. In 1976, Chile increased exports by 39% to 1,082,300 tons of copper contained in all classes valued at $1.23 billion. Under Decree Law No. 1350 effective April 1, 1976, the five major copper mining companies were dissolved and a new State-owned enterprise, Codelco-Chile, was created. Codelco-Chile will operate as a single company, with four operating divisions in Chuquicamata, Salvador, Andina, and El Teniente. The Chuquicamata Div. encompasses both the Chuquicamata and Exotica mines. Codelco-Chile invested over $110 million during the year to replace equipment and improve operating efficiency. Major improvements include the enlargement of the Chuquicamata smelter to handle a capacity of 4,000 tons of feed per day and the installation of the new Sapos reservoir and the Coya-to-Colon water supply system plus a new tailings pond at El Teniente. At El Teniente engineering plans were completed to update mine and mill systems to handle the harder, lower grade ore as mining moves into the deeper primary copper sulfide portion of the ore body.

At El Salvador work has begun on the modernization of all old production facilities from mine through refinery. Work was to be completed between 1977 and 1981. At Andina, work continued on a project to increase mine and mill capacity to 15,400 tons of ore per day and a new molybdenite recovery plant, capable of producing 2 tons of molybdenite concentrate daily started up in October 1976. A molybdenite leach plant was to be completed in 1977.

The Chilean Government continued to delay consummation of several new foreign investment contracts, under negotiation to exploit the undeveloped Andacolla, El Abra, Quebrada Blanca, and Los Pelambres copper deposits. In an effort to improve the foreign investment climate, Chile withdrew from the Andean Pact on October 30, 1976, and the obligations to the Pact's Decision No. 24, restricting foreign investment, the repatriation of capital, and import tariff levels within the region. On March 18, 1976, the Foreign Investment Statute was modified under Decree Law No. 1748 to extend the commitment to complete investment in mining from 8 to 12 years, to limit total tax load for income to 49.5%, and to lighten tariffs on imported machinery and equipment. Also legal discrimination between foreign and local companies would not be allowed.

Iran.—Sar Cheshmeh Copper Mining Co., an Iranian Government-owned company, continued development of the copper mine and metallurgical complex in southern Iran. Delays and cost escalation raised the expected cost of the 160,000-ton copper mine-smelter-refinery complex to $1.4 billion with initial production scheduled for late 1977, and with the refinery due onstream by yearend 1978. Further development drilling suggested that reported reserves of 500 million tons of ore averaging 1.13% copper and 0.03% molybdenum could be more than doubled.

Japan.—Mine production of copper decreased 4% from 1975 to 89,600 tons contributing only 8% to the consumption of refined copper. Reflecting a general pickup in the business activity in the Japanese economy, blister copper production increased 5% to 946,700 tons and refined copper output increased 6% to 952,800 tons. These smelter and refinery production rates represented approximately 70% of capacity.

Japan, the world's third largest consumer of refined copper, following the United States and the U.S.S.R., consumed 1,157,700 tons of copper, an increase of 27% from that of 1975 and the highest consumption since 1973.

With improved consumption and the easing of the Japan Ministry of International Trade and Industry (MITI) ban on exporting copper in July, producers of 172,100 stocks were down 17% from 1975. Japanese merchants and consumers reduced stocks 9% to 111,300 tons. Supported by Government loans of nearly $83 million repayable at an interest rate of 6.5% the nonprofit Metallic Mineral Stockpiling Association, founded by 25 refiners and manufacturers of electrical wire and copper mill products, purchased 55,560 tons of copper. The stockpile purchases were made in four stages, 14,330 tons each in August, September, and October, and 12,570 tons at the end of October.

Korea, Republic of.—In September the Korean Government awarded a contract to three European firms to build a $183 million flash smelter, acid plant, and electrolytic copper refinery complex at Onsan. The Onsan complex will have an initial capacity of 88,000 tons of copper per year and is scheduled to be completed by March 1979.

Malaysia.—The Mamut Mines Development Co., under the management of Overseas Mineral Resources Development Sabah Bhd., a consortium of seven Japanese firms, in a joint venture with the Sabah Government and other Malaysian interests, completed the first full year of production from the Mamut mine in Sabah. The 85,600 tons of a 23.5% concentrate yielded 20,100 tons of contained copper at a rate equal to 67% of planned capacity.

Mexico.—Mexican copper production improved substantially in all areas during the year. Mine production increased 14% to 98,070 tons, smelter output up 12% to 93,890 tons, and refined copper 19% to 83,130 tons.

Industrial Minera Mexico, S.A., in which ASARCO has a 34% interest, increased the output of blister copper 15% to 40,200 tons. Expansion programs completed during the year raised capacities by 85% at the San Martin copper-zinc mine and by 30% and 25% at the Charcas and Santa Barbara lead-zinc-copper mines. Exploration and feasibility work continued on the large El Arco porphyry copper deposit near Guerrero Negro in the Baja California peninsula with reserves estimated at 770 million tons of about 0.5% copper. Development plans called for the treatment of El Arco concentrates at the proposed new La Caridad smelter— refinery complex at Empalme.

Compañia Minera de Cananea, S.A., operated the Cananea mine and smelter to produce 53,800 tons of copper compared with 44,100 tons in 1975. An expansion program designed to increase capacity from 44,000 to 77,000 tons of copper was expected to be completed in early 1977. A further increase to 111,000 tons was under study.

Mexicana de Cobre, S.A., 44% owned by the Mexican Government, continued development of the $600 million La Caridad copper project in Sonora. The 79,000-ton-per-day open pit mine-mill operation was to be followed by a flash smelter and refinery complex at the Port of Empalme near Guaymas with a planned capacity of 175,000 tons of copper per year by early 1978. A detailed description of the project was presented in the June 19, 1976, issue of Skillings Mining Review. Ore reserves were reported at 760 million tons of 0.76% copper and 0.16% molybdenum.

Panama.—On February 25, 1976, the Government of Panama and Texasgulf Inc. signed a joint venture agreement to develop the Cerro Colorado copper deposit. Under the landmark agreement, which may serve as a model for future contracts between national governments and multinational mining companies, Texasgulf will have a 20% equity in the Cerro Colorado Mining Corp. and an option from Panama for the purchase of Texasgulf's 20% equity after 20 years. Texasgulf will conduct and share in the cost of a $50 million feasibility study scheduled for completion by April 1978. In addition, Texasgulf will receive management fees for overseeing the design and construction phase and during the first 15-year management phase of the project. Estimates call for an $800 million mine-smelter-refinery complex with a capacity between 150,000 and 170,000 tons of copper annually to be in production by about 1982. By yearend Texasgulf had confirmed that ore reserves were slightly improved with grades and tonnages in excess of previous estimates of 1 billion tons of 0.65% copper. Indications were that higher copper grades in the upper portion of the ore body may add to the economic viability of the project in its early years.

Papua New Guinea.—Bougainville Copper Pty., Ltd., controlled 53.6% by Conzinc Riotinto of Australia Ltd. (CRA), 20% by the Papua New Guinea Government, and 26.4% by the public, milled 34.4 million tons of a lower grade ore containing 0.64% copper and 0.025 troy ounce of gold per ton. Copper production increased 2% with 658,000 tons of 29.58% copper concentrate containing 193,800 tons of copper. Estimated ore reserves in the Panguna ore body at the end of 1976 were approximately 881 million tons of ore averaging 0.45% copper and 0.015 troy ounce of gold per ton. Differences between the Central Government and Bougainville Island leaders were resolved with Bougainville renamed North Solomons and having more autonomy over local matters. Papua New Guinea, however, will retain control over import-export taxes, corporate taxes, and royalties on natural resources.

Exploration drilling of the OK Tedi deposit in Western Papua New Guinea was completed in 1976 with reserves identified in four areas. The portion of the OK Tedi deposit minable by open pit methods contains 275 million tons grading 0.85% copper, 0.012% molybdenum, and 0.019 troy ounce of gold per ton plus an additional 27.6 million tons averaging 0.084 troy ounce of gold per ton. Outside the pit design limits there are 61 million tons of 0.57% copper plus 29 million tons of underground reserves grading 2.33% copper and 0.052 troy ounce of gold per ton. The Mt. Fubilan Development Co., a consortium, was formed to undertake a 31-month, $9 million feasibility study of the OK Tedi deposit. Dampier Mining Co., a subsidiary of the Broken Hill Proprietary Co. Ltd., was to manage and hold a 37.5% interest in Fubilan. Kupferexplorations Gesellschaft m.b.H., a West German group comprised of Metallgesellschaft, Kabel, and Metallwerk, Gutehoffnungshute, and Siemens, and Degussa held 25% while Amoco Minerals Co., a subsidiary of Standard Oil Co. of Indiana, held the remainder. If OK Tedi is developed the Papua New Guinea Government would have the right to acquire a 20% equity interest with Dampier and Amoco reverting to 30% each and Kupferexplorations to 20%.

With respect to the Frieda River deposit, having known reserves of 400 million tons of 0.47% copper, MIM signed a joint prospecting venture with the Metal Mining Agency of Japan and a consortium of five private Japanese copper smelters. The venture calls for a 5-year exploration and feasibility study over the Frieda River area.

Peru.—Aided by an improved labor situation and the opening of a major new open pit mine, Peruvian copper mine and smelter production increased 12% and 18% to 221,330 and 204,530 tons. Refinery production, with the help of the first full year of operation of the new Ilo plant, increased 165% to 154,451 tons of electrolytic copper. Copper exports in all forms increased 26% to 208,300 tons with refined exports representing 69% of the total compared with only 27% in 1975.

Southern Peru Copper Corp. (SPCC), Peru's largest copper company, milled 16 million tons of 1.05% copper ore at Toquepala compared with 13.8 million tons of 1.06% copper in strike-affected 1975. An additional 8.5 million tons of heap-leach ore grading about 0.38% copper were also treated. SPCC is controlled by ASARCO Inc. (51.5%), Cerro-Marmon Corp. (22.25%), Newmont Mining Corp. (10.25%), and Phelps Dodge Corp. (16%). SPCC (88.5%), in a joint venture with the Royal Dutch Shell-owned company Billiton, B.V. (11.5%), started copper production at its new $726 million Cuajone mine late in the second quarter. The mine is located 550 miles southeast of Lima and over 11,000 feet high in the Andes Mountains. The development period spanned 10 years including 6-1/2 years of construction and involved the removal of 240 million tons of overburden, construction of plant facilities, two new townsites, 130 miles of roads, 17 miles of railroad tunnels, a 35-mile water pipeline, and a seawater desalination plant at the Ilo complex. Ore reserves at yearend 1976 were estimated at 470 million tons of 0.98% copper at a cutoff of 0.45%; 108 million tons of low-grade sulfide reserves ranging from 0.20% to 0.45% copper, and nearly 14 million tons of oxide ore with an average grade of 1.20% copper.

At full capacity of 180,000 tons per year of copper contained in concentrates and oxide ore, Cuajone is exceeded in size by only a few copper mines in the world such as Bingham, Utah, Chuquicamata, and El Teniente in Chile and Bougainville in Papua New Guinea. The mill was initially designed to handle 45,000 tons of ore daily and was operating at about 90% of capacity by yearend. In 1976, the mill produced 117,400 tons of concentrates grading 41.65% copper from 3.86 million tons of 1.61% ore treated. Of the additional 7 million tons of oxide ore mined 2.6 million tons of 2.3% ore was stockpiled, 4.4 million tons of 1% ore was sent to leach dumps and 33,000 tons of 4% copper was used as a smelter flux. Concentrates are moved by rail through 17 miles of tunnel through the mountains to the Toquepala mine and then for 117 miles down to the coastal smelter at Ilo. In conjunction with the Cuajone project, SPCC completed the more than twofold expansion of the Ilo smelter by yearend to a rated capacity of 1,450 dry tons of feed daily or over 520,000 tons annually. In 1976, the Ilo smelter produced 148,100 tons of blister copper, with three quarters credited to Toquepala and the remainder to Cuajone.

Northern Peru Mining Corp., an ASARCO subsidiary, operated the Quiruvilca mine and produced 3,800 tons of copper in concentrates compared with 6,200 tons in 1975.

Compañía Minera del Madrigal, a subsidiary of Homestake Mining Co., processed 277,370 tons of ore, an increase of 7% from that of 1975, at its Madrigal copper-lead-zinc mine near Arequipa, Peru, and produced approximately 11,260 tons of copper concentrates, down 8%. Ore reserves of 1.15 million tons averaged 1.5% copper, 2.6% lead, and 5.0% zinc. The program to increase the mill capacity from 770 to 1,100 tons of ore per day will be completed in 1977.

Most of the approximate 57,000 tons of remaining mine production came from Empresa Minera del Centro del Perú (Centromin), the State-owned mining agency, which operates six underground mines and one open pit copper mine. Centromin has arranged for $176 million in local and external loans to finance the modernization and expansion of its existing copper facilities. At the Cerro de Pasco mine, $15 million will be invested to replace the cementation plant with a solvent extraction-electrowinning plant having a capacity of 7,000 tons per year of copper cathodes. The plant was to be operational by 1979. At the Cobriza mine a $161 million expansion program, to be completed in 1980, will increase mine capacity from 0.7 million to 3.5 million tons of ore per year, and mill capacity to 10,000 tons of ore daily. Annual concentrate output will be increased from 50,000 to 222,000 tons.

Empresa Minera del Peru (Minero Peru) continued development of the $100 million Cerro Verde mine and heap leaching project with production at a rate of 36,000 tons per year of copper scheduled to begin in June 1977. Development of the massive underlying Santa Rosa ore body and expansion of the Ilo refinery from 165,000 to 330,000 tons of refined copper per year are not envisaged for completion until after 1980.

Of the major deposits still awaiting development, SPCC is negotiating with Minero Peru with regard to development of the Quellaveco ore body located between the Toquepala and Cuajone mines. Quellaveco reserves have been reported at 440 million tons grading 0.80% copper. A feasibility study on the Michiquillay project was completed in October by the Metal Mining Agency of Japan and a group of seven Japanese smelters led by Mitsui Mining & Smelting Co., Ltd. The study confirmed ore reserves at 1 billion tons grading 0.69%-0.76% copper and estimated 6 years and $700 million would be required to develop the mine. The project would be developed as a joint venture between Minero Peru (51%) and Japanese interests (49%), and it would include a 44,000-ton-per-day mill with a capacity to produce 113,500 tons per year of copper in concentrates. Concentrates will be slurried and piped from the mine site to the Port of Pacasmayo for export to Japan.

Philippines.—The Philippines maintained its eighth ranking among world copper producers with 14 mining companies increasing production 2% to 255,185 tons of copper contained in concentrates and direct shipping grade ore. Plans for a Government-sponsored copper smelter appeared to firm up by late 1976. The former Copper Smelter Corp. has been reorganized into the Philippine Associated Smelting and Refining Corp. (PASAR). PASAR is a consortium of 11 local mining companies led by Atlas Consolidated Mining and Development Corp., Marcopper Mining Corp., Lepanto Consolidated Mining Co., Philex Mining Corp., and Marinduque Mining & Industrial Corp. These five companies will provide 36%, the Government 34%, and as yet unselected foreign investors 30% of the estimated $250 million needed to build a 93,000-ton Outokumpu flash smelter. Pending final environmental clearances the smelter site will be located 60 miles from Manila at Bantiqui Point, San Juan Batangas Province. The smelter is scheduled to come onstream in 1979-80.

Atlas Consolidated., one of the largest copper producers in Asia, milled 24.5 million tons of 0.51% copper ore, improved its recovery rates, and increased production of copper contained in 374,550 tons of concentrates by 1% in 1976 to 113,600 tons. The company operated the Frank, Lutopan, and Biga mines on Cebu Island, Central Philippines. On June 1, construction began on the new $100 million Carmen open pit located between the Frank and Biga pits and an associated 35,000-ton-per-day mill with startup scheduled for late 1977. With the completion of the Carmen project, the combined Atlas milling capacity of 104,000 tons of ore per day will equal the Bougainville, Papua New Guinea mine in size. Atlas reports reserves at yearend at 1.08 billion tons grading 0.46% copper.

Marcopper Mining Corp., a subsidiary of Placer Development Ltd., operating at the expanded capacity of 27,000 tons per day of ore, milled 9.7 million tons of 0.59% copper ore, and increased production of copper contained in concentrates 37% to 52,400 tons. Minable reserves at yearend in the Tapian ore zone were 85 million tons at a 0.40% cutoff and a 0.58% average grade of copper. At the Tapian mine site a discovery of a new San Antonio ore body located under the tailings disposal area was announced. Preparations for developing this deposit, containing 200 million tons of 0.57% copper, were underway.

Marinduque Mining & Industrial Corp. operated the Sipalay open pit in Negros Oriental and the Bagacay pit in Samar. At Sipalay, a record production of 30,000 tons of copper from 6.3 million tons of ore represented increases of 12% and 14% over 1975. Production at Bagacay decreased 15% to 5,980 tons of copper contained in 26,190 tons of concentrates. In addition, the mine produced 13,750 tons of direct shipping grade ore. Grade of the direct shipping ore was 11.52% copper. Ore reserves were reported at 718 million tons of ore grading 0.492% copper at Sipalay and 1 million tons of 4.42% copper and 2.78% zinc at Bagacay.

Philex Mining Corp. increased production 13% in 1976 to 33,780 tons of copper contained in concentrates. The company operated the Santo Thomas II underground mine near Benguet, northern Luzon, with reserves of 166 million tons of ore grading 0.43% copper and 0.031 troy ounce of gold per ton. With production of 190,000 ounces of gold, Philex was also the largest gold producer in the country.

Lepanto Consolidated Mining Co. resumed operations at the Lepanto underground mine in Mt. Province, northern Luzon on September 15. Production through yearend amounted to 4,600 tons of copper contained in concentrates. The mill treated 226,600 tons of ore yielding 14,815 tons of a 31% copper concentrate. However, during the year approximately 58,000 tons of concentrates were shipped to ASARCO's Tacoma, Wash., smelter for processing reducing the stockpile of concentrates on hand to about 17,000 tons. Reserves at the Lepanto mine were reduced at yearend to 8 million tons of 2.57% copper and 0.013 troy ounce of gold per ton.

Western Minolco, operator of the Boneng and Lobo mines in Benguet, northern Luzon, produced 39,270 tons of concentrates from 4.5 million tons of ore milled in 1976 containing 9,860 tons of copper. The bulk of production came from the Lobo pit during the year. An expansion program to increase the initial mill capacity of 16,500 tons to 33,000 tons of ore per day will be completed in April 1977. Combined ore reserves at Boneng-Lobo are estimated at 102 million tons of 0.338% copper and 0.012 troy ounce of gold per ton.

Several new copper projects progressed during the year in both the planning and construction phases. These included Consolidated Mines Ino project scheduled to be operational by mid-1977 at a mill capacity of 16,500 tons of ore per day. Mining will be based on reserves of 112 million tons of 0.53% copper. Benquet Consolidated Inc. is currently arranging financing for a $100 million, 19,000-ton-per-day mine-mill development of its Dizon deposit containing reserves of 86 million tons of 0.47% copper. CCDP Mining Corp. is planning an 11,000-ton-per-day milling operation by 1979 at its Basay, Negros Oriental property. Reserves are reported at 113 million tons of 0.544% copper. Sabena Mining Corp. is planning to develop reserves of 38 million tons of 0.502% copper at New Bataan on Davao Del Norte. Mining plans call for an 11,000-tons-per-day ore handling capacity to be in place by 1979.

Poland.—In 1976 ore mined totaled 21.7 million tons yielding 300,000 tons of copper, an increase of 15% over that of 1975. Copper mine production came mainly from three underground mines; Lubin, Polkowice, and Rudna, all located in the sedimentary Kupferschiefer beds of the Legnica—Glogow copper region. The two older Konrad and Lena mines also contributed to mine production. Smelter and refinery production increased 9% and 8%, respectively, to 305,000 and 297,600 tons each during the year. Initial production from the new 165,000-ton Glogow copper refinery was reported to have begun in late 1976. Full production is expected by 1980.

Rhodesia, Southern.—M.T.D. (Mangula) Ltd., a Messina Transvaal subsidiary, operated the Mangula, Norah, and Silverside mines during the year ended September 30, 1976. At the Mangula mine, located 80 miles northwest of Salisbury, 1.3 million tons of 1.08% copper ore were treated yielding 13,250 tons of copper contained in concentrates, down 11% from that of 1975. The Norah and Silverside mines produced an additional 2,474 tons and 2,227 tons of copper in concentrates. Proven ore reserves were 3.1 million tons of 1.21% copper at the Norah mine with Silverside mine reserves expected to be depleted by March 1977.

Lomagundi Smelting and Mining Ltd., also a Messina Transvaal subsidiary, produced 1,442 tons of copper in concentrate from mining and milling 261,200 tons of 0.86% copper ore from the Alaska mine. At 1976 copper prices, operation at the Alaska, Hans, and Angwa sections of the Alaska mine was no longer viable and production was stopped. The Shackleton mine yielded 9,950 tons of copper in concentrate from 657,000 tons of 1.62% copper ore. Proved reserves at yearend were 1.4 million tons of 1.80% copper at the Shackleton mine. Production for the year ending September 30 at the Coronation Syndicate's Inyati mine amounted to 5,175 tons of copper.

South Africa, Republic of.—O'okiep Copper Co. Ltd., a subsidiary of Newmont Mining, mined and milled 2.6 million tons of ore with an average grade of 1.35% copper which yielded 32,600 tons of blister copper compared with 33,800 tons in 1975. Development work was resumed at the Divide and Brandkloof mines to bring them into production in late 1977 and 1978. The Nababeep South mine was activated in late 1976 and the Hoits mine was to be restarted in early 1977. A $20 million development effort began in midyear aimed at bringing the Carolusberg deep ore body into production in 1981. Carolusberg reserves were currently estimated at 11 million tons of 1.82% copper with substantial additional potential. Total ore reserves at O'okiep mines at yearend 1976 were estimated at 30 million tons averaging 1.67% copper.

Palabora Mining Co. Ltd. produced 102,900 tons of copper, a 2% increase over that of 1975. The 21 million tons of 0.55% copper ore milled was equal to the 1975 level. A $100 million expansion of the open pit mining and ore processing facilities was completed by yearend. Milling capacity was increased from an average 58,000 tons to 82,000 tons of ore per day equivalent to 138,000 tons of copper annually. The capacity of the electrolytic refinery was expanded 95% to 156,000 tons to handle the entire Palabora copper output.

Messina (Transvaal) Development Co. mined and milled 860,000 tons of 1.24% copper ore from its Messina mine which yielded 9,810 tons of copper in concentrate, down 6% from that of 1975. The tonnage of proved ore reserves at yearend was estimated at 4.7 million tons averaging 1.37% copper.

South-West Africa, Territory of.—Tsumeb Corp. Ltd. mined 489,000 tons of ore from the Tsumeb mine averaging 4.25% copper, 9.04% lead, and 2.39% zinc. The Kombat and Asis Ost mines produced 65,300 tons of ore containing 1.49% copper and 1.92% lead before operations were suspended in March. Mining was to be resumed at these mines in late 1978 at the same time production from the new Asis West is scheduled to begin. The Matchless mine, near Windhoek, produced 112,000 tons of ore averaging 2.40% copper.

Oamites Mining Co. (Pty.) Ltd. (75% Falconbridge) milled 662,500 tons of ore grading 1.31% copper. Metal recovery decreased 7% to 7,037 tons of copper.

Yugoslavia.—Estimated primary production of copper by Rudarsko Topionicarski Bazen (RTB), Bor, Serbia, in 1976 included 132,400 tons of copper in concentrates, 181,200 tons of blister copper, and 134,000 tons of refined copper. RTB operated a mine, a flotation plant, and smelter at Bor, and a mine and a flotation plant at Majdanpek. Development work continued on the 660-million-ton, 0.5% copper deposit at Veliki Krivelj with plans for an annual capacity of 66,000 tons of copper to be reached by 1981. Work also continued on the development of the second major copper-producing facility in Yugoslavia at Bucim, near Radoviste, Macedonia. Work on mine and beneficiation plant at the Bucim copper deposit, designed to handle 4 million tons of ore annually, continued during the year and was scheduled to reach an annual capacity of 23,000 tons of copper in concentrates by 1978. A 28,000-ton electrolytic refinery will also be built near Bucim.

Zaire.—Mining the highest grade copper ore in the world with an average reserve content of 4.52% copper, Zaire produced ore containing 490,100 tons of copper, 10% lower than in 1975. Total smelter and refinery production dropped by 12% and 71% to 450,000 tons and 72,750 tons respectively, from that of 1975. Disruptions caused by the closure of the Benguela railroad from Shaba Province to the Angolan Port of Lobito, a result of the Angolan Civil War, and the closure of the Mozambique-Rhodesian border had a strong impact on the economy and copper industry. Transportation difficulties in getting food, spare parts, coke, coal, and diesel oil into Shaba were major factors in the reduced levels of production experienced, particularly in the smelters and electrolytic refineries. Copper exports are channeled out of Shaba by way of a tedious internal route to the Zairian Port of Matadi: by southern railroads to the Port of East London, South Africa; or by the Tanzania-Zambia Railway (Tazara) to the Port of Dar es Salaam, Tanzania.

The Government mining agency, La Générale des Carrières et des Mines du Zaire (Gécamines), which operates 10 mines, 5 mills, 1 copper smelter at Lubumbashi, and 2 copper-cobalt refineries at Shituru and Luilu in Shaba Province, produced 449,410 tons of copper including 147,700 tons of blister and 302,030 tons of copper in refined shapes. Plans to increase annual production of copper to 628,000 tons were still in progress with completion scheduled for 1979 at a cost of over $600 million. Plans called for the construction of a 138,000-ton-per-year flash smelter and a 100,000-ton-per-year electrolytic copper refinery, all near Kolwezi, Shaba. As part of the expansion program, two new open pit mines at Dikuluwe and Mashambe, with combined reserves estimated at 171 million tons of 4.1% copper and 0.3% cobalt, opened in late 1975 but operated at a low rate because of diesel fuel shortages. Gécamines refinery at Lubumbashi was scheduled to be expanded from 143,000 tons per year to 176,000 tons per year by 1980.

The joint Zairian Government-private Japanese concern Société de Dévelopment Industriel et Miniére du Zaire (SODIMIZA), operated the Mushoshi mine and mill in Shaba Province. Production for 1976 increased 11% to 39,600 tons of copper contained in 111,660 tons of concentrates. SODIMIZA continued development of the Kinsenda mine during the year with production expected to begin in late 1977. Reserves at Kinsenda are reported at 35 million tons of 5.5% copper.

Société Minière de Tenke-Fungurume (SMTF) is controlled by the Republic of Zaire (20%) and a consortium comprised of Charter Consolidated Ltd. and associated companies (28%), Amoco Minerals Co. (28%), Mitsui & Co. (14%), Bureau des Recherches Geologiques et Miniéres (3.5%), Omnium des Mines, S.A. (3.5%), and Leon Templesman & Son Inc. (3%). In January 1976, owing to regional fuel shortages and serious financial support problems, all work was suspended on the 7,150-ton cobalt and 165,000-ton copper mine-electrowinning refinery complex originally scheduled for completion in 1977. Cost estimates had escalated from $600 million to $900 million. Approximately $275 million had been expended on the project when the suspension decision was made. If construction is resumed, a smaller 95,000-ton facility will probably be built. In the interim, the project will be kept on a care-and-maintenance basis at a cost of about $400,000 per month.

Zambia.—The Zambian copper industry, which was nationalized in 1975, continued to be plagued by low copper prices and rapidly escalating costs. As a result of the tight financial situation most new development programs were deferred. The opening of the Tazara railroad to the port of Dar Es Salaam in Tanzania eased export transportation problems. However, difficulties in maintaining spare part inventories and in retaining skilled expatriate mining engineers and technicians seriously affected copper production levels. Mine production in 1976 increased 5% to 781,391 tons of recoverable copper, while blister production increased 7% to 778,127 tons, and refined production increased 10% to 766,040 tons.

In the year ended June 30, 1976, Roan Consolidated Mines, Ltd. mined 17.3 million tons of ore with an average grade of 1.99% yielding 304,100 tons of copper from the Mufulira, Luanshya, Chambishi, Chibuluma, and Kalengwa mines. RCM also operated two smelters at Mufulira and Luanshya which produced 306,932 tons of anode copper. The Mufulira and Ndola Copper refineries produced 347,850 tons of copper cathodes, 275,680 tons of which were cast into wirebars. The electrowinning plant at Chambishi produced 17,330 tons of leach cathodes. Work continued on a $200 million expansion program to increase mine production at the Baluba section of Luanshya, Chibuluma, and Chambishi and to extend the Chambishi leach plant. The new anode slimes treatment plant at Ndola was scheduled to start production in October 1976. Ore reserves at all RCM mines were estimated to total 362 million tons of ore with an average grade of 2.88% copper. The Mufulira and Luanshya mines contain 83% of this reserve total.

Nchanga Consolidated Mines, Ltd., for the year ended March 31, 1976, produced 424,842 tons of finished copper from operations at the Rokana, Konkola, and Chingola mine divisions, the smelter-refinery complex at Kitwe, and from the refinery at Chingola. At the Rokana division, mine output from the Mindola and Bwana Mkubwa operations decreased 22% to 122,230 tons of copper. Breakdowns at the concentrator and in the tailings pipeline contributed to the production losses. The 14,000-ton-capacity Mindola open pit mine and oxide treatment plant were placed on a care and maintenance basis for economic reasons at yearend 1975, while expansion of the Mindola underground operations continued. At the Konkola division, mine production decreased 15% to 48,930 tons. Production of copper at the Chingola division decreased 7% to 341,160 tons. Of this total, 35% came from the Chingola underground mine, 51%

from the Nchanga open pit, and the balance from four other open pits. The Chingola tailings leach plant during the fiscal year treated 9.3 million tons of low-grade tailings and oxide concentrates yielding 81,800 tons of electrowon cathode copper. NCCM controlled, as of December 30, 1975, 637 million tons of ore reserves averaging 2.96% copper with 55% of these held within the Chingola division. Reserves reported include indicated and possible ore.

TECHNOLOGY

An article described the history of exploration for porphyry copper deposits in the Southwestern United States and speculated on the discovery of additional deposits buried under gravels and volcanics.[2] Another article detailed the use of mapping, geochemical, electromagnetic, and gravity work in discovery of strata-bound massive sulfide copper deposits.[3] The mechanism for the dissolution and precipitation of copper in strataform deposits, especially of the red-bed type, was the subject of a published study.[4] A geologic description and postulated genesis of a stratabound massive sulfide nickel-copper deposit was published.[5] Estimated costs to produce 165,000 tons per year of white metal from two copper-nickel hypothetical open pit mines operating on the Duluth gabbro was the subject of an open-file report.[6] Review of the development of selected copper deposits indicated that the required lead times ranged from 1 to 15 years for major exploration, 1 to 4 years for open pit development, and 4 to 8 years for underground development.[7]

An article reviewed the properties of ocean nodules and the economic parameters of several proposed processing methods.[8] Details were published on a smelt-leach process[9] and on an ammoniacal leach-ion exchange-selective stripping process to recover the copper, nickel, and cobalt in the nodules.[10]

The application of rock mechanics technology to design open pit mines for proper safety and efficient operation was described.[11] Techniques have been developed to stabilize tailings material to prevent an increase into underground mine workings caused by subsidence of ground beneath the tailings pond.[12] Research on thermal fragmentation of semiconductive rock indicated an unlikely application to a copper-bearing shale formation.[13]

Leaching experiments in columns simulating 80 and 200-foot deep cores through a leach dump were performed. Results indicated that in the 200-foot system lack of oxygen restricted biological activity; activity increased when air was introduced. However, the free diffusion of oxygen was restricted by clay formation and fines accumulation at specific levels within the column.[14] Research showed that presence of thermophylic bacteria enhanced copper extraction in leaching of prophyry copper samples containing chalcopyrite as the primary mineral.[15] An analysis of a ferric

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chloride leaching process on chalcopyrite concentrate indicated favorable operating costs.[16] Studies were conducted on the use of solvent extraction systems in conjunction with leaching sulfides with a ferric or cupric chloride solution.[17] A kinetic investigation of copper cementation in a revolving drum and a pilot-scale test on the use of shredded automobile scrap for cementation were reported.[18]

It was established that an arseniferous copper concentrate could be smelted in an electric-arc furnace with results comparable to use of a gas-fired reverberatory furnace.[19] An electrothermic reduction process to produce blister copper from dead-burned copper sulfide concentrates recovered 98.4% of the contained copper and permitted efficient collection of the sulfur.[20] Fuel consumption, economic advantage, and compliance with environmental regulations were considered in a review article on various pyrometallurgical processes to replace the reverberatory furnace.[21] A review of sulfur dioxide emission control data for major Japanese smelters showed capture of 91% to 99.7% of the sulfur in the smelter feed.[22]

Studies showed that an individual, with proper equipment, could disassemble about 100 automobile starters or 150 generators in 8 hours with a scrap copper yield of 280 and 390 pounds, respectively.[23] Other studies detailed energy requirements for production of refined copper.[24]

Research on use of zinc-based solders on copper and copper alloys indicated a fourfold increase in service life over conventional solders.[25]

A case study of the development of a medium-size massive sulfide copper deposit, including a required environmental impact statement was published.[26]

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Table 2.—Copper produced from domestic ores, by source

(Thousand short tons)

Year	Mine	Smelter	Refinery
1972	1,665	1,649	1,680
1973	1,718	1,705	1,698
1974	1,597	1,532	1,421
1975	1,413	1,374	1,286
1976	1,606	1,461	1,423

Table 3.—Copper ore and recoverable copper produced, by mining method

(Percent)

Year	Open pit		Underground	
	Ore	Copper[1]	Ore	Copper[2]
1972	85	80	15	20
1973	89	78	11	22
1974	89	81	11	19
1975	89	80	11	20
1976	90	84	10	16

[1]Includes copper from dump leaching.
[2]Includes copper from in-place leaching.

Table 4.—Mine production of recoverable copper in the United States, by month

(Short tons)

Month	1975	1976
January	131,272	119,319
February	117,793	115,507
March	117,595	132,516
April	123,219	134,931
May	126,890	135,433
June	111,476	128,140
July	95,488	126,244
August	114,510	142,096
September	118,701	142,825
October	128,568	146,210
November	111,658	141,209
December	116,196	141,156
Total	1,413,366	1,605,586

Table 5.—Mine production of recoverable copper in the United States, by State

(Short tons)

State	1972	1973	1974	1975	1976
Arizona	908,612	927,271	858,783	813,211	1,024,421
California	598	369	194	344	375
Colorado	3,944	3,123	3,012	3,560	2,431
Idaho	2,942	3,625	2,841	3,192	3,362
Maine	1,220	1,107	1,522	2,024	1,766
Michigan	67,260	72,221	67,012	73,690	43,707
Missouri	11,509	10,273	12,665	14,258	11,050
Montana	123,110	132,466	131,131	87,959	91,111
Nevada	101,119	93,702	84,101	81,210	58,160
New Mexico	168,034	204,742	196,585	146,263	172,360
Pennsylvania	2,611	1,845	--	--	W
Tennessee	11,310	8,500	6,304	10,041	11,131
Utah	259,507	256,589	230,593	177,155	185,458
Other States[1]	3,064	2,107	2,259	459	254
Total	1,664,840	1,717,940	1,597,002	1,413,366	1,605,586

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1]Includes Pennsylvania and Washington (1976).

Table 6.—Twenty-five leading copper-producing mines in the United States in 1976, in order of output

Rank	Mine	County and State	Operator	Source of copper
1	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper ore, copper precipitates.
2	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper ore, copper precipitates, copper tailings.
3	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
4	Sierrita	Pima, Ariz	Duval Sierrita Corp	Do.
5	Twin Buttes	do	Anamax Mining Co	Do.
6	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Copper ore, copper precipitates.
7	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
8	Ray Pit	Pinal, Ariz	Kennecott Copper Corp	Do.
9	Pima	Pima, Ariz	Cyprus Pima Mining Co	Copper ore.
10	Metcalf	Greenlee, Ariz	Phelps Dodge Corp	Copper ore, copper tailings.
11	Pinto Valley	Gila, Ariz	Cities Service Co	Copper ore, copper precipitates.
12	Chino	Grant, N. Mex	Kennecott Copper Corp	Do.
13	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Copper ore.
14	White Pine	Ontonagon, Mich	White Pine Copper Co	Do.
15	Magma	Pinal, Ariz	Magma Copper Co	Do.
16	Inspiration	Gila, Ariz	Inspiration Consolidated Copper Co.	Copper ore, copper precipitates.
17	Mission	Pima, Ariz	ASARCO Inc	Copper ore.
18	Yerington	Lyon, Nev	The Anaconda Company	Copper ore, copper precipitates.
19	Continental	Grant, N. Mex	UV Industries, Inc	Do.
20	Silver Bell	Pima, Ariz	ASARCO Inc	Do.
21	Sacaton Unit	Pinal, Ariz	do	Copper ore.
22	Bagdad	Yavapai, Ariz	Cyprus Bagdad Copper Co	Do.
23	Lakeshore	Pinal, Ariz	Hecla Mining Company	Do.
24	Esperanza	Pima, Ariz	Duval Corp	Copper ore, copper precipitates.
25	Copper Canyon	Lander, Nev	do	Do.

Table 7.—Mine production of recoverable copper in 1976, by method of treatment

Method of treatment	Ore treated (thousand short tons)	Recoverable copper: Thousand pounds	Recoverable copper: Percent yield	Remarks
Copper ore:				
By concentration	258,371	2,600,209	0.50	See table 9.
By smelting	260	1,678	.32	See table 10.
By leaching	25,105	[1]312,714	.62	See table 11.
Total	283,736	2,914,601	.51	
Dump and in-place leaching	--	252,288	--	See table 11.
Miscellaneous from cleanup, tailings, and noncopper ores	--	44,282	--	
Total	XX	3,211,171	XX	--

XX Not applicable.
[1]Includes 150,384,677 pounds of electrowon copper.

Table 8.—Copper ore shipped directly to smelters or concentrated in the United States, by State in 1976, with copper, gold, and silver content in terms of recoverable metal

State	Ore shipped or concentrated (thousand short tons)	Recoverable metal content: Copper, Thousand pounds	Copper, Percent	Gold (troy ounces)	Silver (troy ounces)	Value of gold and silver per ton of ore
Arizona	173,472	1,657,015	0.48	97,636	7,276,850	$0.25
Idaho	141	1,852	.66	W	W	W
Michigan	3,801	87,414	1.15	--	310,837	.36
Montana	16,781	156,001	.46	19,843	2,935,682	.91
Nevada	7,820	76,498	.49	28,819	486,325	.73
New Mexico	25,016	298,991	.60	13,219	765,800	.20
Tennessee[1]	2,034	22,261	.55	W	W	W
Utah	29,567	301,854	.51	W	W	W
Other States	--	--	--	[2]166,264	[2]1,856,641	[2].91
Total[3]	258,631	2,601,887	.50	325,781	13,632,135	.39

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1]Copper-zinc ore.
[2]Includes data for Idaho, Tennessee, and Utah.
[3]Data may not add to totals shown because of independent rounding.

Table 9.—Copper ore concentrated[1] in the United States, by State in 1976, with content in terms of recoverable copper

State	Ore concentrated (thousand short tons)	Recoverable copper content: Thousand pounds	Percent
Arizona	173,292	1,655,558	0.48
Idaho	141	1,852	.66
Michigan	3,801	87,414	1.15
Montana	16,781	156,000	.46
Nevada	7,790	76,302	.49
New Mexico	24,966	298,967	.60
Tennessee[2]	2,034	22,261	.55
Utah	29,567	301,854	.51
Total[3]	258,371	2,600,209	.50

[1]Includes following methods of concentration: "Dual process" (leaching followed by concentration); "LPF"(leach-precipitation-flotation); and froth flotation.
[2]Copper-zinc ore.
[3]Data may not add to totals shown because of independent rounding.

Table 10.—Copper ore shipped directly to smelters[1] in the United States, by State in 1976, with content in terms of recoverable copper

State	Ore shipped to smelters: Short tons	Recoverable copper content: Pounds	Percent
Arizona	180,069	1,457,523	0.40
Montana	35	702	1.00
Nevada	29,788	195,752	.33
New Mexico	50,173	23,644	.02
Utah	1	118	5.90
Total	260,066	1,677,739	.32

[1]Primarily smelter fluxing material.

Table 11.—Copper precipitates (from dump or in-place leaching) shipped directly to smelters and copper ore and tailings leached (heap, vat, or tank) in the United States, by State in 1976, with content in terms of recoverable copper

State	Precipitates shipped (short tons)	Recoverable copper content (pounds)	Ore leached (short tons)	Recoverable copper content (pounds)	Percent
Arizona	70,117	98,625,236	[1]20,574,374	[2]287,527,188	0.70
California	102	124,534	--	--	--
Montana	22,785	25,824,354	--	--	--
Nevada	10,821	14,619,681	4,530,184	25,186,416	.28
New Mexico	28,227	44,778,845	--	--	--
Utah	42,604	68,314,990	[3]15	[4]300	1.00
Total	174,656	252,287,640	25,104,573	312,713,904	.62

[1]Includes 11,355,466 short tons of ore leached for electrowinning, and excludes newly generated tailings.
[2]Includes 150,384,377 pounds of electrowon copper.
[3]Ore leached for electrowinning.
[4]Electrowon copper.

Table 12.—Copper ore smelted and copper ore concentrated in the United States, and average yield in copper, gold, and silver

Year	Smelting ore		Concentrating ore		Total				
	Thousand short tons	Yield in copper, percent	Thousand short tons[1] [2]	Yield in copper, percent	Thousand short tons[1]	Yield in copper, percent	Yield per ton in gold, ounce	Yield per ton in silver, ounce	Value per ton in gold and silver
1972	484	1.68	248,663	0.55	266,831	0.55	0.0019	0.059	$0.21
1973	337	1.40	272,688	.53	289,998	.53	.0018	.058	.32
1974	305	1.26	269,016	.50	293,443	.49	.0014	.048	.45
1975	357	1.85	239,614	.48	263,003	.47	.0014	.051	.44
1976	260	.32	258,371	.50	283,736	.51	.0013	.053	.39

[1]Includes some ore classed as copper-zinc and minor amount of tailings.
[2]Excludes tank or vat and heap leaching. (See tables 7 and 11.)

Table 13.—Copper produced by primary smelters in the United States

(Short tons)

Year	Domestic	Foreign	Secondary	Total
1972	1,649,130	41,263	69,017	1,759,410
1973	1,705,065	38,898	77,815	1,821,778
1974	1,532,066	37,750	79,543	1,649,359
1975	1,374,324	72,804	49,357	1,496,485
1976	1,461,256	73,366	51,045	1,585,667

Table 14.—Primary and secondary copper produced by primary refineries and electrowinning plants in the United States

(Short tons)

	1972	1973	1974	1975	1976
PRIMARY					
From domestic ores, etc.:[1]					
Electrolytic	1,499,005	1,510,334	1,275,545	1,140,754	1,221,140
Electrowon	21,938	26,485	23,167	30,972	103,941
Fire refined	159,469	161,518	122,193	114,463	97,642
Total	1,680,412	1,698,337	1,420,905	1,286,189	1,422,723
From foreign ores, etc.:[1]					
Electrolytic[2]	160,781	170,151	233,753	157,189	116,585
Electrowon	--	--	W	W	W
Fire refined	32,040	W	W	W	--
Total refinery production of primary copper	1,873,233	1,868,488	1,654,658	1,443,378	1,539,308
SECONDARY					
Electrolytic[2]	341,581	377,523	398,976	265,413	281,070
Electrowon	--	--	W	W	W
Fire refined	16,667	14,290	13,543	5,467	7,616
Total secondary	358,248	391,813	412,519	270,880	288,686
Grand total	2,231,481	2,260,301	2,067,177	1,714,258	1,827,994

W Withheld to avoid disclosing individual company confidential data; included in "Electrolytic."
[1]The separation of refined copper into metal of domestic and foreign origin is only approximate, as accurate separation is not possible at this stage of processing.
[2]Includes electrowon and fire refined quantities indicated by symbol W.

Table 15.—Copper cast in forms at primary refineries in the United States

	1975		1976	
	Thousand short tons	Percent	Thousand short tons	Percent
Billets	61	3	50	3
Cakes	67	4	76	4
Cathodes	765	45	910	50
Ingots and ingot bars	132	8	125	7
Wire bars	676	39	643	35
Other forms	13	1	24	1
Total	1,714	100	1,828	100

Table 16.—Production, shipments, and stocks of copper sulfate

(Short tons)

Year	Production		Shipments	Stocks Dec.31[1]
	Quantity	Copper content		
1972	38,052	9,513	37,964	5,828
1973	43,360	10,840	44,092	4,580
1974	42,092	10,523	43,598	3,074
1975	35,614	9,204	31,822	6,866
1976	32,122	8,421	30,431	8,557

[1] Some small quantities are purchased and used by producing companies, so that the figures given do not balance exactly.

Table 17.—Byproduct sulfuric acid[1] (100% basis) produced in the United States

(Short tons)

Year	Copper plants[2]	Lead plants	Zinc plants[3]	Total
1972	1,010,614	859,103 (lead and zinc plants combined)		1,869,717
1973	1,088,322	146,591	819,537	2,054,450
1974	1,277,440	132,594	830,969	2,241,003
1975	1,784,744	129,756	711,769	2,626,269
1976	2,281,591	145,872	799,773	3,227,236

[1]Includes acid from foreign materials.
[2]Excludes acid made from pyrites concentrates.
[3]Excludes acid made from native sulfur.

Table 18.—Secondary copper produced in the United States

(Short tons)

	1972	1973	1974	1975	1976
Copper recovered as unalloyed copper	447,409	484,623	513,308	355,512	390,729
Copper recovered in alloys[1]	853,564	892,534	831,012	616,453	754,545
Total secondary copper[1]	1,300,973	1,377,157	1,344,320	971,965	1,145,274
Source:					
New scrap	842,779	890,943	860,888	602,792	726,148
Old scrap	458,194	486,214	483,432	369,173	419,126
Percentage equivalent of domestic mine output	78	80	84	69	71

[1]Includes copper in chemicals, as follows: 1972—3,038; 1973—3,704; 1974—2,649; 1975—2,480; and 1976—4,007.

Table 19.—Copper recovered from scrap processed in the United States by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1975	1976
New scrap:		
Copper-base	585,426	705,392
Aluminum-base	17,103	20,444
Nickel-base	248	282
Zinc-base	15	30
Total	602,792	726,148
Old scrap:		
Copper-base	358,496	404,144
Aluminum-base	10,226	14,516
Nickel-base	349	321
Tin-base	7	8
Zinc-base	95	137
Total	369,173	419,126
Grand total	971,965	1,145,274

Form of recovery	1975	1976
As unalloyed copper:		
At primary plants	270,880	288,686
At other plants	84,632	102,043
Total	355,512	390,729
In brass and bronze	571,991	700,844
In alloy iron and steel	1,927	2,186
In aluminum alloys	39,583	47,017
In other alloys	472	491
In chemical compounds	2,480	4,007
Total	616,453	754,545
Grand total	971,965	1,145,274

Table 20.—Copper recovered as refined copper, in alloys and in other forms from copper-base scrap processed in the United States

(Short tons)

Recovered by—	From new scrap		From old scrap		Total	
	1975	1976	1975	1976	1975	1976
Secondary smelters	53,606	57,419	162,508	188,162	216,114	245,581
Primary copper producers	139,230	144,215	131,650	144,471	270,880	288,686
Brass mills	381,744	486,878	26,140	30,207	407,884	517,085
Foundries and manufacturers	11,426	14,698	37,383	39,455	48,809	54,153
Chemical plants	1,159	2,182	1,330	1,849	2,489	4,031
Total	587,165	705,392	359,011	404,144	946,176	1,109,536

Table 21.—Production of secondary copper and copper-alloy products in the United States

(Short tons)

Item produced from scrap	1975	1976
UNALLOYED COPPER PRODUCTS		
Refined copper by primary producers	270,880	288,686
Refined copper by secondary smelters	73,606	86,469
Copper powder	10,957	15,564
Copper castings	69	10
Total	355,512	390,729
ALLOYED COPPER PRODUCTS		
Brass and bronze ingots:		
Tin bronzes	33,474	34,421
Leaded red brass and semired brass	89,799	120,233
High-leaded tin bronze	23,304	26,143
Yellow brass	9,824	13,089
Manganese bronze	9,110	9,850
Aluminum bronze	6,743	6,736
Nickel silver	2,636	3,090
Silicon bronze and brass	2,584	2,911
Copper-base hardeners and master alloys	10,765	12,204
Total	188,239	228,677
Brass-mill products	510,384	649,713
Brass and bronze castings	31,759	36,486
Brass powder	571	614
Copper in chemical products	r2,480	4,007
Grand total	r1,088,945	1,310,226

rRevised.

Table 22.—Composition of secondary copper-alloy production

(Short tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production: [1]							
1975	144,209	9,297	13,419	20,848	422	44	188,239
1976	173,060	11,398	16,870	26,831	449	69	228,677
Secondary metal content of brass-mill products:							
1975	408,959	341	2,305	94,652	4,083	44	510,384
1976	517,676	322	3,371	124,485	3,826	33	649,713
Secondary metal content of brass and bronze castings:							
1975	25,860	857	1,963	3,045	1	33	31,759
1976	29,195	946	2,211	4,059	31	44	36,486

[1] About 92% from scrap and 8% from other than scrap.

Table 23.—Stocks and consumption of purchased copper scrap in the United States in 1976

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks Dec. 31
SECONDARY SMELTERS						
No. 1 wire and heavy copper	2,184	26,942	3,449	23,579	27,028	2,098
No. 2 wire, mixed heavy and light copper	5,121	61,006	13,869	46,031	59,900	6,227
Composition or red brass	5,270	58,026	12,299	46,306	58,605	4,691
Railroad-car boxes	324	1,978	--	1,852	1,852	450
Yellow brass	5,102	47,647	4,971	41,246	46,217	6,532
Cartridge cases and brass	32	289	--	195	195	126
Auto radiators (unsweated)	4,075	57,887	--	57,823	57,823	4,139
Bronze	1,692	20,274	3,267	16,653	19,920	2,046
Nickel silver and cupronickel	789	3,043	357	2,728	3,085	747
Low brass	613	2,829	1,223	1,659	2,882	560
Aluminum bronze	191	490	427	140	567	114
Low-grade scrap and residues	13,205	78,830	62,561	16,151	78,712	13,323
Total	38,598	359,241	102,423	254,363	356,786	41,053
PRIMARY PRODUCERS						
No. 1 wire and heavy copper	5,043	115,247	59,425	58,244	117,669	2,621
No. 2 wire, mixed heavy and light copper	3,528	140,451	80,489	47,851	128,340	15,639
Refinery brass	}	4,625	436	3,794	4,230	}
	9,619					17,730
Low-grade scrap and residues	}	183,267	47,765	127,786	175,551	}
Total	18,190	443,590	188,115	237,675	425,790	35,990
BRASS MILLS[1]						
No. 1 wire and heavy copper	11,246	159,250	130,585	28,665	159,250	12,814
No. 2 wire, mixed heavy and light copper	4,415	71,778	69,928	1,850	71,778	5,042
Yellow brass	23,886	269,074	269,074	--	269,074	26,342
Cartridge cases and brass	8,090	78,028	78,005	23	78,028	9,334
Bronze	995	4,219	4,219	--	4,219	800
Nickel silver and cupronickel	7,228	33,791	33,791	--	33,791	4,558
Low brass	4,334	45,959	45,959	--	45,959	4,026
Aluminum bronze	34	355	355	--	355	53
Total[1]	60,228	662,454	631,916	30,538	662,454	62,969
FOUNDRIES, CHEMICAL PLANTS, AND OTHER MANUFACTURERS						
No. 1 wire and heavy copper	2,224	29,821	8,640	20,547	29,187	2,858
No. 2 wire, mixed heavy and light copper	734	10,471	3,337	6,591	9,928	1,277
Composition or red brass	507	4,446	1,368	3,150	4,518	435
Railroad-car boxes	597	5,098	--	4,325	4,325	1,370
Yellow brass	523	7,951	5,549	2,499	8,048	426
Auto radiators (unsweated)	1,211	9,797	--	10,258	10,258	750
Bronze	84	660	77	521	598	146
Nickel silver and cupronickel	--	88	--	82	82	6
Low brass	36	1,486	814	641	1,455	67
Aluminum bronze	59	474	86	363	449	84
Low-grade scrap and residues	93	--	64	--	64	29
Total	6,068	70,292	[2]19,935	[2]48,977	[2]68,912	7,448
GRAND TOTAL						
No. 1 wire and heavy copper	20,697	331,260	202,099	131,035	333,134	20,391
No. 2 wire, mixed heavy and light copper	13,798	283,706	167,623	102,323	269,946	28,185
Composition or red brass	5,777	62,472	13,667	49,456	63,123	5,126
Railroad-car boxes	921	7,076	--	6,177	6,177	1,820
Yellow brass	29,511	324,672	279,594	43,745	323,339	33,300
Cartridge cases and brass	8,122	78,317	78,005	218	78,223	9,460
Auto radiators (unsweated)	5,286	67,684	--	68,081	68,081	4,889
Bronze	2,771	25,153	7,563	17,174	24,737	2,992
Nickel silver and cupronickel	8,017	36,922	34,148	2,810	36,958	5,311
Low brass	4,983	50,274	47,996	2,300	50,296	4,653
Aluminum bronze	284	1,319	868	503	1,371	251
Low-grade scrap and residues[3]	22,917	266,722	110,826	147,731	258,557	31,082
Total	123,084	1,535,577	942,389	571,553	1,513,942	147,460

[1]Brass-mill stocks include home scrap; purchased scrap consumption assumed equal to receipts, so lines in brass-mill and grand total sections do not balance.

[2]Of the totals shown, chemical plants reported the following: Unalloyed copper scrap, 2,287 tons new and 1,936 old.

[3]Includes refinery brass.

Table 24.—Consumption of copper and brass materials in the United States by principal consuming groups

(Short tons)

Year and item	Primary producers	Brass mills	Wire mills	Foundries, chemical plants, and miscellaneous users	Secondary smelters	Total
1975:						
Copper scrap	372,505	518,364	--	60,098	301,601	1,252,568
Refined copper[1]	--	438,970	1,061,255	29,800	4,483	1,534,508
Brass ingot	--	5,645	--	[2]188,669	--	194,314
Slab zinc	--	106,942	--	2,084	6,300	115,326
Miscellaneous	--	--	--	150	12,717	12,867
1976:						
Copper scrap	425,790	662,454	--	68,912	356,789	1,513,945
Refined copper[1]	--	584,755	1,364,048	35,563	7,519	1,991,885
Brass ingot	--	8,320	--	[2]228,204	--	236,524
Slab zinc	--	157,398	--	2,252	6,594	166,244
Miscellaneous	--	--	--	200	5,702	5,902

[1]Detailed information on consumption of refined copper will be found in table 28.
[2]Shipments to foundries by smelters minus increase in stocks at foundries.

Table 25.—Foundry consumption of brass ingot, by types, in the United States

(Short tons)

	1972	1973	1974	1975	1976
Tin bronzes	40,526	47,963	53,702	40,982	33,117
Leaded red brass and semired brass	145,617	136,012	117,038	84,839	97,732
Yellow brass	36,865	34,820	58,922	65,799	23,167
Manganese bronze	9,933	10,868	9,773	6,843	5,695
Hardeners and master alloys	5,291	6,633	6,053	4,420	3,385
Nickel silver	2,838	2,908	3,104	2,437	2,249
Aluminum bronze	6,222	6,882	7,743	5,287	5,923
Total	247,292	246,086	256,335	210,607	171,268

Table 26.—Foundry consumption of brass ingot by type, refined copper, and copper scrap, in the United States in 1976, by geographic division and State

(Short tons)

Geographic division and State	Tin bronzes	Leaded red brass and semi-red brass	Yellow brass	Manganese bronze	Hardeners and master alloys	Nickel silver	Aluminum bronze	Total brass ingot	Refined copper consumed	Copper scrap consumed
New England:										
Connecticut	779	2,056	1,393	20			243	4,494	626	373
Massachusetts	827	1,825	610	289	12	393	59	3,864	1,004	49
Maine, New Hampshire, Rhode Island, Vermont	144	2,068	178	251			36	2,825		--
Total	1,750	5,949	2,181	560	12	393	338	11,183	1,630	422
Middle Atlantic:										
New Jersey	762	506	133	140			15	1,625	2,206	3,202
New York	1,165	7,212	1,122	441	68	53	88	10,080	1,851	1,846
Pennsylvania	6,033	6,709	1,468	471	1,103	360	1,555	17,699	5,150	3,773
Total	7,960	14,427	2,723	1,052	1,171	413	1,658	29,404	9,207	8,821
East North Central:										
Illinois	1,999	11,864	718	603	82	14	637	15,917	845	1,679
Indiana	3,181	6,062	973	368	812	279	37	11,653	2,105	8,627
Michigan	425	4,776	356	355			498	6,469	6,182	2,500
Ohio	7,124	10,617	3,946	612	207	14	430	22,950	3,386	6,006
Wisconsin	1,539	4,905	1,612	96	781	297	196	9,426	5,599	2,877
Total	14,268	38,224	7,605	2,034	1,882	604	1,798	66,415	18,117	21,689

West North Central:										
Iowa, Kansas, Minnesota	254	4,420	463	273	76	9	137	5,628	1,442	543
Missouri, Nebraska, South Dakota	122	1,290	540	248			391	2,595		678
Total	376	5,710	1,003	521	76	9	528	8,223	1,442	1,221
South Atlantic:										
Delaware, District of Columbia, Florida, Georgia, Maryland	424	395	69	114	4	680	75	1,759	164	450
North Carolina, South Carolina, Virginia, West Virginia	482	5,404	319	193			264	6,664	93	4,192
Total	906	5,799	388	307	4	680	339	8,423	257	4,642
East South Central:										
Alabama, Kentucky, Mississippi, Tennessee	3,328	11,300	3,346	438	147	68	105	18,732	1,749	9,803
West South Central:										
Arkansas, Louisiana, Oklahoma, Texas	2,575	2,615	4,305	190	1	36	903	10,625	1,192	912
Mountain:										
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah	208	378	95	49	3	--	14	747	240	397
Pacific:										
California	1,634	13,262	1,518	438	89	46	112	17,099	797	14,434
Oregon and Washington	112	68	3	106	--	--	128	417	431	2,348
Total	1,746	13,330	1,521	544	89	46	240	17,516	1,228	16,782
Grand total	33,117	97,732	23,167	5,695	3,385	2,249	5,923	171,268	35,062	64,689

Table 27.—Primary refined copper supply and withdrawals on domestic account

(Short tons)

	1972	1973	1974	1975	1976
Production from domestic and foreign ores,etc	1,873,233	1,868,488	1,654,658	1,443,378	1,539,308
Imports [1]	192,379	202,955	313,569	146,805	381,524
Stocks Jan. 1[1]	75,000	57,000	37,000	101,000	207,000
Total available supply	2,140,612	2,128,443	2,005,227	1,691,183	2,127,832
Copper exports [1]	182,743	189,396	126,526	172,426	111,887
Stocks Dec. 31 [1]	57,000	37,000	101,000	207,000	190,000
Total	239,743	226,396	227,526	379,426	301,887
Apparent withdrawals on domestic account [2]	1,901,000	1,902,000	1,778,000	1,312,000	1,826,000

[1] May include some copper refined from scrap.
[2] Excludes copper, if any, delivered to industry from national stockpile sales.

Table 28.—Refined copper consumed by class of consumer

(Short tons)

Year and class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1975:							
Wire mills	312,066	745,102	W	--	--	4,087	1,061,255
Brass mills	171,812	21,571	72,452	97,236	75,899	--	438,970
Chemical plants	--	--	--	--	--	467	467
Secondary smelters	2,542	W	1,931	--	W	10	4,483
Foundries	1,176	897	11,661	W	W	264	13,998
Miscellaneous[1]	2,742	217	5,421	214	178	6,563	15,335
Total	490,338	767,787	91,465	97,450	76,077	11,391	1,534,508
1976:							
Wire mills	588,604	766,863	W	--	--	8,581	1,364,048
Brass mills	263,834	23,792	92,141	121,911	83,077	--	584,755
Chemical plants	--	--	--	--	--	501	501
Secondary smelters	3,645	W	3,872	--	--	2	7,519
Foundries	1,193	1,159	12,653	--	W	361	15,366
Miscellaneous[1]	3,627	W	7,077	148	W	8,844	19,696
Total	860,903	791,814	115,743	122,059	83,077	18,289	1,991,885

W Withheld to avoid disclosing individual company confidential data; included in "Other."
[1]Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.

Table 29.—Stocks of copper in the United States, Dec. 31

(Short tons)

Year	Blister and materials in process of refining[1]	Refined copper: Primary producers	Wire rod mills	Brass mills	Other[2]	New York Commodity Exchange
1972	281,000	57,000	50,000	28,000	5,400	57,800
1973	265,000	37,000	42,000	30,000	5,600	5,900
1974	324,000	101,000	108,000	36,000	6,900	43,200
1975	312,000	207,000	119,000	31,000	6,100	100,000
1976	321,000	190,000	114,000	36,000	7,000	201,000

[1] Includes copper in transit from smelters in the United States to refineries therein.
[2] Includes secondary smelters, chemical plants, foundries, and miscellaneous plants.

Table 30.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York in 1976

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June
No. 2 copper scrap	36.98	37.92	39.76	41.95	44.10	43.66
No. 1 composition scrap	31.98	32.92	34.76	36.23	37.10	36.45
No. 1 composition ingot	63.00	63.00	67.20	71.98	73.00	73.00
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 2 copper scrap	46.93	45.73	43.71	38.48	35.00	34.10	40.69
No. 1 composition scrap	37.18	37.05	35.21	31.06	29.50	28.60	34.06
No. 1 composition ingot	73.48	75.00	73.00	69.67	69.00	69.00	70.03

Source: Metal Statistics, 1977.

Table 31.—Average monthly quoted prices of electrolytic copper for domestic delivered, in the United States and for spot copper at London

(Cents per pound)

Month	1975			1976		
	Domestic delivered		London spot[1]	Domestic delivered		London spot[1]
	American Metal Market	Metals Week	Metals Week	American Metal Market	Metals Week	Metals Week
January	68.86	69.03	54.91	63.63	63.63	54.09
February	64.32	64.18	57.44	63.63	63.63	55.29
March	64.32	64.18	60.85	64.73	64.68	60.25
April	64.32	64.18	60.28	69.26	69.24	68.50
May	64.32	63.78	56.81	70.63	70.63	68.56
June	63.67	63.14	54.04	70.63	70.63	70.26
July	63.02	62.48	55.43	74.63	74.63	74.66
August	64.31	63.79	57.91	74.63	74.63	69.73
September	64.31	63.79	54.86	74.63	74.63	66.20
October	64.31	63.79	53.46	72.34	72.06	58.30
November	64.31	63.79	53.44	70.63	70.63	57.98
December	64.31	63.79	52.18	66.10	65.77	58.41
Average	64.53	64.16	56.08	69.62	69.56	63.92

[1]Based on average monthly rates of exchange.

Table 32.—Average weighted prices of copper delivered

(Cents per pound)

Year	Domestic copper	Foreign copper
1972	51.2	48.6
1973	59.5	80.8
1974	77.3	93.5
1975	64.2	56.0
1976	69.6	63.5

Source: Metals Week.

Table 33.—U.S. exports of copper, by class and country

Year and country	Ore, concentrates, and matte (copper content)		Ash and residues (copper content)		Refined		Scrap		Blister	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1975	8,307	$6,917	6,599	$6,267	172,426	$225,418	45,002	$40,793	1,545	$1,270
1976:										
Africa	2	3	--	--	43	87	49	54	56	47
Argentina	--	--	--	--	36	50	170	198	--	--
Belgium-Luxembourg	6,766	5,493	1,105	1,474	952	1,424	2,658	1,701	1,762	1,740
Brazil	--	--	--	--	2,832	3,900	51	108	--	--
Canada	3,371	3,205	500	400	4,674	6,391	6,374	7,632	11	9
Denmark	--	--	--	--	1,854	2,545	--	--	--	--
Finland	--	--	35	1	440	666	--	--	--	--
France	(1)	1	15	28	20,958	30,443	4	4	--	--
Germany, West	136	235	2,457	643	26,815	35,987	1,771	1,301	105	128
India	--	--	--	--	--	--	363	405	--	--
Israel	--	--	--	--	11	23	--	--	--	--
Italy	--	--	--	--	15,638	23,592	1,137	855	--	--
Japan	2,958	3,010	319	559	4,664	6,450	4,723	5,399	16	13
Korea, Republic of	1,507	1,572	--	--	2	3	12,481	13,034	16	9
Mexico	--	--	293	16	30	68	2,018	1,656	43	36
Netherlands	1	1	--	--	4,961	6,776	209	256	(1)	1
Oceania	--	--	1	4	4	10	--	--	--	--
Pakistan	--	--	--	--	--	--	35	14	--	--
Philippines	--	--	--	--	150	216	--	--	--	--
Saudi Arabia	9	12	--	--	7	13	--	--	--	--
Spain	--	--	106	106	29	44	1,496	1,502	705	628
Sweden	--	--	--	--	5,013	7,122	619	290	--	--
Switzerland	--	--	--	--	443	609	--	--	--	--
Taiwan	--	--	164	16	5	12	2,156	1,818	--	--
Thailand	--	--	--	--	--	--	79	91	--	--
United Kingdom	99	154	117	208	20,321	27,183	776	479	4	4
Venezuela	--	--	--	--	1,216	1,612	--	--	2	2
Other	4	4	1	2	789	1,163	304	282	3	5
Total	14,853	13,690	5,113	3,457	111,887	156,389	37,473	37,079	2,723	2,622

	Pipes and tubing		Plates and sheets		Wire and cable, bare		Wire and cable, insulated		Other copper manufactures[2]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1975	2,202	$6,280	186	$646	3,721	$9,266	79,630	$223,943	9,518	$14,158
1976:										
Africa	170	438	4	19	180	393	4,376	10,505	29	36
Argentina	6	29	--	--	11	32	35	246	(1)	2
Belgium-Luxembourg	1	4	--	--	26	97	427	2,015	53	394
Brazil	18	79	--	--	9	48	258	1,447	7	22
Canada	1,500	3,098	328	751	743	1,909	20,766	27,950	873	1,417
Denmark	1	2	--	--	3	8	84	509	--	--
Finland	--	--	--	--	(1)	4	5	99	2	3
France	29	104	11	40	13	68	184	1,848	7	12
Germany, West	14	94	6	24	18	69	662	3,315	5	9
India	--	--	--	--	(1)	1	10	132	(1)	1
Israel	28	55	11	30	2	20	424	3,156	12	29
Italy	(1)	2	1	5	1	5	147	1,759	24	97
Japan	2	6	(1)	1	3	20	405	2,690	47	155
Korea, Republic of	--	--	--	--	2	12	167	1,933	--	--
Mexico	26	86	3	13	1,984	5,296	7,846	16,275	17	68
Netherlands	1	6	6	21	19	44	251	1,417	73	100
Oceania	19	54	(1)	4	7	22	308	3,274	15	66
Pakistan	10	28	(1)	2	(1)	1	49	166	--	--
Philippines	16	46	1	5	4	13	192	672	146	219
Saudi Arabia	73	187	(1)	1	593	1,097	6,820	12,779	76	185
Spain	--	--	--	--	5	38	103	682	127	286
Sweden	--	--	1	1	28	55	54	843	17	35
Switzerland	--	--	--	--	2	9	102	469	(1)	3
Taiwan	36	93	--	--	47	187	890	2,865	7	13
Thailand	--	--	--	--	(1)	1	17	112	1	2
United Kingdom	142	389	9	41	47	241	862	5,280	95	219
Venezuela	35	79	4	13	4	25	451	1,555	2,484	3,675
Other	425	1,056	38	96	1,038	2,712	11,321	36,165	805	1,387
Total	2,552	5,935	423	1,067	4,789	12,427	57,216	140,158	4,922	8,435

[1] Less than 1/2 unit.
[2] Does not include wire cloth: 1975-2,268,914 square feet ($1,064,516); 1976-1,238,812 square feet ($832,196).

Table 34.—U.S. exports of copper, by class

	Ore, concentrate and matte (copper content)		Blister		Refined copper and semimanufactures	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	12,488	$17,387	2,660	$3,568	202,203	$448,584
1975	8,307	6,917	1,545	1,270	258,165	465,553
1976	14,853	13,960	2,723	2,622	176,877	313,377

	Other copper manufactures[1]		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	8,332	$17,583	225,683	$487,122
1975	9,518	14,158	277,535	487,898
1976	4,923	8,435	199,376	338,394

[1]Does not include wire cloth: 1974-1,954,750 square feet ($869,778); 1975-2,268,914 square feet ($1,064,516); 1976-1,238,812 square feet ($832,196).

Table 35.—U.S. exports of copper-base alloy (including brass and bronze), by class

Class	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ingots	304	$1,195	483	$2,042
Scrap and waste	99,213	84,153	76,706	64,120
Bars, rods, shapes	7,754	13,197	7,584	13,945
Plates, sheets, strips	3,187	12,375	4,126	18,318
Pipes and tubing	6,609	19,193	6,213	19,596
Pipe fittings	6,953	23,146	8,588	28,365
Plumber's brass goods	1,277	4,484	1,472	4,592
Welding rods and wire	2,477	7,939	2,403	8,655
Castings and forgings	997	3,181	958	2,868
Powder and flakes	1,266	2,901	1,849	4,513
Foil	217	796	283	1,490
Articles of copper and copper-base alloys, n.e.c	(1)	7,278	(1)	8,766
Total	130,254	179,838	110,665	177,270

[1] Quantity not reported.

Table 36.—U.S. exports of unfabricated copper-base alloys[1] ingots, bars, rods, shapes, sheets, and strip

Year	Quantity (short tons)	Value (thousands)
1974	23,181	$62,598
1975	11,245	26,767
1976	12,193	34,305

[1] Includes brass and bronze.

Table 37.—U.S. exports of copper sulfate (blue vitriol)

Year	Quantity (short tons)	Value (thousands)
1974	1,815	$2,138
1975	1,248	2,067
1976	2,071	2,935

Table 38.—U.S. exports of copper scrap, by country

Country	Unalloyed copper scrap 1975 Quantity (short tons)	Unalloyed copper scrap 1975 Value (thousands)	Unalloyed copper scrap 1976 Quantity (short tons)	Unalloyed copper scrap 1976 Value (thousands)	Copper alloy scrap 1975 Quantity (short tons)	Copper alloy scrap 1975 Value (thousands)	Copper alloy scrap 1976 Quantity (short tons)	Copper alloy scrap 1976 Value (thousands)
Argentina	453	$538	170	$198	2,035	$2,101	83	$59
Belgium-Luxembourg	3,998	3,105	2,658	1,701	5,289	3,628	8,889	5,710
Brazil	15	62	51	108	310	280	111	82
Canada	4,755	5,575	6,374	7,632	6,838	6,307	6,194	6,961
Denmark	--	--	--	--	199	159	80	50
Finland	--	--	--	--	116	62	354	391
France	101	90	4	4	2,016	1,382	4,442	2,582
Germany:								
East	83	56	--	--	190	130	--	--
West	4,184	3,825	1,771	1,301	9,804	9,929	3,809	3,481
Hong Kong	644	668	282	269	821	706	722	680
India	46	46	363	405	1,543	1,396	3,091	2,637
Italy	702	587	1,137	855	11,862	9,371	9,452	7,282
Japan	7,118	7,220	4,723	5,399	23,038	20,045	15,563	13,986
Korea, Republic of	9,945	9,560	12,481	13,034	10,905	9,446	10,093	9,113
Mexico	1,104	845	2,018	1,656	303	236	254	187
Netherlands	558	519	209	256	2,705	2,455	815	805
Norway	115	119	--	--	167	160	20	22
Pakistan	803	871	35	14	1,829	1,650	40	35
Spain	3,882	2,715	1,496	1,502	5,823	5,203	5,128	4,703
Sweden	303	385	619	290	3,042	1,917	728	511
Switzerland	627	615	--	--	1,604	1,410	1,444	1,318
Taiwan	4,325	2,265	2,156	1,818	2,981	2,750	3,009	1,586
Thailand	136	139	79	91	2,586	515	176	166
Turkey	--	--	--	--	--	--	379	360
United Kingdom	295	272	776	479	2,421	2,428	1,494	1,233
Venezuela	360	198	--	--	429	121	139	119
Other	450	518	71	67	r357	r366	197	61
Total	45,002	40,793	37,473	37,079	99,213	84,153	76,706	64,120

r Revised.

Table 39.—U.S. imports for consumption of copper scrap, by country

Country	Unalloyed copper scrap (copper content)			
	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	77	$84	60	$50
Bahamas	11	8	32	35
Belgium-Luxembourg	59	96	8	14
Canada	7,679	7,663	11,199	11,218
Chile	24	25	1,098	1,491
Dominican Republic	329	286	277	285
France	226	533	112	242
Germany, West	87	107	17	13
Guatemala	65	37	213	149
Honduras	65	53	27	23
Hong Kong	76	84	137	149
Jamaica	125	77	86	55
Japan	37	86	36	43
Mexico	4,202	3,844	5,507	4,541
Netherlands	129	233	59	77
Netherlands Antilles	272	265	234	124
Nicaragua	30	28	181	176
Panama	231	220	7	6
Trinidad and Tobago	36	29	64	67
United Kingdom	46	54	25	19
Other	593	647	356	454
Total	14,399	14,459	19,735	19,231

Country	Copper alloy scrap					
	1975			1976		
	Gross weight (short tons)	Content (short tons)	Value (thousands)	Gross weight (short tons)	Content (short tons)	Value (thousands)
Australia	16	10	$24	--	--	--
Bahamas	170	106	101	151	96	$97
Belgium-Luxembourg	242	130	194	20	14	17
Canada	6,820	4,461	5,828	10,865	6,924	10,122
Dominican Republic	132	94	81	184	146	128
Germany, West	60	31	49	--	--	--
Guatemala	9	6	4	2	2	1
Haiti	18	13	13	8	6	6
Hong Kong	320	206	481	1,446	1,112	1,329
Israel	--	--	--	27	27	27
Jamaica	2	1	1	17	10	1
Japan	--	--	--	78	76	70
Mexico	723	474	449	1,126	714	760
Netherlands Antilles	14	10	9	122	96	87
Nicaragua	4	3	3	88	62	62
Panama	177	115	149	389	265	336
Poland	221	115	186	--	--	--
Trinidad and Tobago	24	17	10	13	9	11
United Kingdom	--	--	--	39	39	32
Other	59	39	57	68	48	55
Total	9,011	5,831	7,639	14,643	9,646	13,141

Table 40.—U.S. imports[1] of unmanufactured copper (copper content), by class and country

Year and country	Ore, concentrates		Matte		Blister	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	53,421	$76,504	2,624	$12,293	207,830	$393,553
1975:						
Australia	2,134	1,723	--	--	7	13
Belgium-Luxembourg	--	--	--	--	(2)	1
Botswana	--	--	5,489	20,374	--	--
Canada	38,958	46,922	75	29	4	4
Chile	18	(2)	19	35	26,283	27,007
Honduras	2,094	706	--	--	--	--
Japan	9	10	27	24	--	--
Mexico	2,461	1,054	--	--	8,822	11,598
Nicaragua	410	421	--	--	--	--
Norway	--	--	--	--	--	--
Peru	6,077	6,746	--	--	30,951	32,423
Philippines	12,601	14,199	--	--	--	--
Poland	117	40	--	--	--	--
South Africa, Republic of	--	--	3,153	14,451	2,470	2,679
South-West Africa, Territory of	--	--	--	--	20,414	23,154
United Kingdom	--	--	1	10	--	--
Yugoslavia	--	--	--	--	--	--
Other	(2)	(2)	328	858	--	--
Total	64,879	71,821	9,092	35,781	88,951	96,879
1976:						
Australia	465	332	--	--	9	17
Belgium-Luxembourg	--	--	--	--	--	--
Botswana	--	--	14,224	55,665	--	--
Canada	47,179	60,696	110	88	158	131
Chile	--	--	--	--	30,817	35,280
Honduras	160	169	--	--	--	--
Italy	--	--	--	--	--	--
Japan	--	--	--	--	--	--
Mexico	4	1	--	--	3,144	3,467
New Guinea	1,949	2,884	--	--	--	--
Nicaragua	533	611	--	--	--	--
Norway	--	--	--	--	--	--
Peru	4,323	5,351	--	--	6,726	8,269
Philippines	15,047	19,295	--	--	--	--
Rhodesia	1,025	574	--	--	--	--
South Africa, Republic of	--	--	3,949	22,524	--	--
South-West Africa, Territory of	--	--	--	--	2,521	2,780
United Kingdom	--	--	--	--	--	--
Yugoslavia	--	--	--	--	--	--
Zaire	--	--	--	--	--	--
Zambia	--	--	--	--	1,108	1,407
Other	2	(2)	--	--	1	2
Total	70,687	89,913	18,283	78,277	44,484	51,353

See footnotes at end of table.

Table 40.—U.S. imports[1] of unmanufactured copper (copper content), by class and country—Continued

Year and country	Refined		Scrap		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	313,569	$551,726	31,158	$50,717	608,602	$1,084,793
1975:						
Australia	1,273	1,409	77	84	3,491	3,229
Belgium-Luxembourg	7,405	8,204	59	96	7,464	8,301
Botswana	--	--	--	--	5,489	20,374
Canada	70,747	88,484	7,679	7,663	117,463	143,102
Chile	28,626	30,378	24	25	54,970	57,445
Honduras	--	--	65	53	2,159	759
Japan	8,259	10,469	37	86	8,332	10,589
Mexico	912	993	4,202	3,844	16,397	17,489
Nicaragua	--	--	30	28	440	449
Norway	242	292	--	--	242	292
Peru	6,864	7,011	--	--	43,892	46,180
Philippines	--	--	--	--	12,601	14,199
Poland	--	--	--	--	117	40
South Africa, Republic of	--	--	--	--	5,623	17,130
South-West Africa, Territory of	--	--	--	--	20,414	23,154
United Kingdom	771	1,157	46	54	818	1,221
Yugoslavia	21,494	21,347	--	--	21,494	21,347
Other	212	342	2,180	2,526	2,720	3,726
Total	146,805	170,086	14,399	14,459	324,126	389,026
1976:						
Australia	1,329	1,525	60	50	1,863	1,924
Belgium-Luxembourg	3,664	3,846	8	14	3,672	3,860
Botswana	--	--	--	--	14,224	55,665
Canada	94,025	123,115	11,199	11,218	152,671	195,248
Chile	69,873	81,295	1,098	1,491	101,788	118,066
Honduras	--	--	27	23	187	192
Italy	3,307	3,175	--	--	3,307	3,175
Japan	--	--	36	43	36	43
Mexico	424	536	5,507	4,541	9,079	8,545
New Guinea	--	--	--	--	1,949	2,884
Nicaragua	--	--	181	176	714	787
Norway	180	204	--	--	180	204
Peru	29,034	32,274	--	--	40,083	45,894
Philippines	--	--	--	--	15,047	19,295
Rhodesia	162	217	--	--	1,187	791
South Africa, Republic of	992	1,046	--	--	4,941	23,570
South-West Africa, Territory of	--	--	--	--	2,521	2,780
United Kingdom	3,316	3,510	25	19	3,341	3,529
Yugoslavia	44,984	49,599	--	--	44,984	49,599
Zaire	2,582	2,779	--	--	2,582	2,779
Zambia	127,162	149,881	--	--	128,270	151,288
Other	490	323	1,594	1,656	2,087	1,981
Total	381,524	453,325	19,735	19,231	534,713	692,099

[1] Data are general imports, that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Less than 1/2 unit.

Table 41.—U.S. imports for consumption of copper (copper content), by class

Year	Ore and concentrates: Quantity (short tons)	Ore and concentrates: Value (thousands)	Matte: Quantity (short tons)	Matte: Value (thousands)	Blister: Quantity (short tons)	Blister: Value (thousands)
1974	84,728	$121,422	2,426	$12,033	200,607	$383,491
1975	29,301	35,649	5,675	20,560	78,969	90,846
1976	35,197	49,861	14,097	54,878	19,388	22,144

Year	Refined: Quantity (short tons)	Refined: Value (thousands)	Scrap: Quantity (short tons)	Scrap: Value (thousands)	Total value (thousands)
1974	313,349	$551,442	31,109	$50,641	$1,119,029
1975	142,945	166,159	14,399	14,459	327,673
1976	381,343	453,279	19,735	19,231	599,393

Table 42.—Copper: World mine production by country[1]

(Short tons)

Country	1974	1975	1976[p]
North and Central America:			
Canada[2]	[r]905,417	808,904	823,570
Cuba[e]	[r]3,200	[r]3,300	3,300
Dominican Republic	[e]500	--	--
Guatemala	1,994	2,822	3,185
Mexico	91,128	86,196	98,073
Nicaragua[3]	1,957	711	696
United States[2]	1,597,002	1,413,366	1,605,586
South America:			
Argentina	347	202	[e]220
Bolivia[4]	[r]8,962	7,045	5,277
Brazil	3,390	2,119	[e]2,200
Chile	994,394	913,043	1,108,042
Colombia[e]	80	80	80
Ecuador	197	263	[e]300
Peru	233,241	[2]197,340	[2]221,331
Europe:			
Albania[e 5]	[r]8,540	8,540	8,800
Austria	2,962	2,186	1,254
Bulgaria	55,160	60,583	59,525
Czechoslovakia[e]	[r]5,200	[r]5,500	5,500
Finland	39,850	42,770	42,118
France	432	551	[e]550
Germany, East	--	[e]1,700	[e]1,700
Germany, West[2 6]	1,911	2,162	1,778
Greece	883	1,533	1,080
Hungary[e]	1,300	1,300	1,300
Ireland[3]	[e]13,942	10,803	4,519
Italy[6]	915	1,011	1,010
Norway[6]	26,587	30,991	34,728
Poland[e]	218,300	260,000	300,000
Portugal[6]	6,226	5,577	4,955
Romania[5]	[e r]37,500	[e r]41,000	44,644
Spain[6 7]	37,807	43,344	[e]44,000
Sweden	44,795	44,791	51,987
U.S.S.R.[e 2 5]	816,000	843,000	880,000
United Kingdom	478	504	[e]550
Yugoslavia	123,587	126,649	132,409
Africa:			
Algeria[e]	410	440	440
Botswana	2,623	7,154	13,759
Congo (Brazzaville)[3]	1,025	1,010	450
Ethiopia[e]	440	440	440
Kenya[e]	80	80	80
Mauritania	22,133	17,861	10,396
Morocco[3]	5,952	5,291	[e]4,400
Mozambique[3]	689	755	[e]770
Rhodesia, Southern[8]	43,315	43,531	34,969
South Africa, Republic of	197,436	197,233	217,023
South-West Africa, Territory of[3 9]	35,801	[e]43,000	[e]48,500
Uganda	13,496	9,370	9,921
Zaire	550,524	547,111	490,098
Zambia	769,364	746,177	781,391

See footnotes at end of table.

Table 42.—Copper: World mine production by country[1] —Continued

(Short tons)

Country	1974	1975	1976[p]
Asia:			
Burma[10]	77	94	101
China, People's Republic of[e]	110,000	110,000	110,000
Cyprus[6]	12,346	10,913	11,023
India	30,953	42,990	54,895
Indonesia	71,210	69,997	75,398
Iran[11]	1,980	1,980	1,631
Israel	12,100	8,270	--
Japan[3 12]	90,538	93,674	89,618
Korea, North[e]	14,000	14,000	14,000
Korea, Republic of	3,080	2,944	2,486
Malaysia	[e]55	4,189	20,062
Philippines	[r]249,077	249,366	255,185
Taiwan[e]	2,760	2,100	2,200
Turkey	42,765	40,319	[e]35,800
Oceania:			
Australia	277,055	241,363	239,683
Papua New Guinea[3]	[r]202,491	190,123	193,793
Total	[r]8,047,959	7,671,661	8,212,779

[e]Estimate. [p]Preliminary. [r]Revised.

[1]Data presented represent copper content (recoverable where indicated) of ore mined wherever possible. If such data are not available the nonduplicative total copper content of ores, concentrates, matte, metal and/or other copper-bearing products measured at the least stage of processing for which data are available has been used.

[2]Recoverable.

[3]Copper content of concentrate produced.

[4]Corporacion Minera de Bolivia (COMIBOL) production plus exports by medium and small mines.

[5]Smelter production.

[6]Includes copper content of cupriferous pyrites.

[7]Excludes an unreported quantity of copper in iron pyrites which may or may not be recovered.

[8]Year ending September 30 of that stated.

[9]Data are compiled from operating company reports of Tsumeb Corp., Ltd., General Mining and Finance Corp. Ltd. for Klein Aub Koper Maatskappy Ltd.'s mine near Rehoboth, and Falconbridge Nickel Mines Ltd. for Oamites Mining Co. (Pty.) Ltd., Oamites mine. Data for General Mining and Finance Corp. Ltd. are for fiscal years ending June 30 of that stated, while data for the other companies are for the calendar years.

[10]Copper content of matte produced.

[11]Year beginning March 21 of that stated.

[12]Copper content of run-of-mine production was as follows in short tons: 1974—90,985; 1975—93,952; 1976—90,181.

Table 43.—Copper: World smelter production by country[1]

(Short tons)

Country	1974	1975	1976[p]
North America:			
Canada	[r]568,351	547,076	538,582
Mexico[2]	86,322	84,188	93,889
United States[3]	1,569,816	1,447,128	1,534,622
South America:			
Argentina[e]	90	90	90
Brazil	2,756	1,442	--
Chile[4]	798,403	798,513	943,908
Peru	194,560	173,081	204,533
Europe:			
Albania[e]	8,540	8,540	8,800
Austria	2,870	([5])	--
Belgium[e 6]	17,600	22,000	22,000
Bulgaria[e]	53,000	[r]66,000	62,000
Czechoslovakia[e]	6,600	[r]7,700	6,600
Finland	48,569	51,731	56,787
Germany, East[e]	--	1,650	1,650
Germany, West	191,834	185,326	200,069
Hungary[e]	1,300	1,300	1,300
Norway[7]	34,984	29,045	26,253
Poland[e]	215,000	[r]280,000	305,000
Portugal	3,970	3,527	[e]3,500
Romania[e]	[r]37,500	[r]41,000	44,600
Spain	142,449	157,383	155,727
Sweden	45,125	45,793	51,236
U.S.S.R.[e]	816,000	843,000	880,000
Yugoslavia	195,063	178,587	181,220

Table 43.—Copper: World smelter production by country[1] —Continued

(Short tons)

Country	1974	1975	1976[p]
Africa:			
Rhodesia, Southern[e] [8]	45,200	47,400	42,000
South Africa, Republic of	162,920	165,020	175,598
South-West Africa, Territory of[9]	51,381	40,135	31,000
Uganda	9,827	9,149	8,800
Zaire[10]	[r]515,440	509,929	449,996
Zambia	[r]782,089	726,453	778,127
Asia:			
China, People's Republic of[e]	110,000	110,000	110,000
India	12,100	26,460	27,230
Iran[11]	7,170	7,700	7,700
Japan	1,049,954	905,496	946,710
Korea, North	14,000	[r]14,000	14,000
Korea, Republic of	13,670	22,377	32,739
Taiwan[11]	4,400	6,173	4,400
Turkey	32,603	29,707	26,460
Oceania: Australia	[r]216,195	198,457	186,842
Total	[r]8,067,651	7,792,556	8,163,968

[e]Estimate. [p]Preliminary. [r]Revised.

[1]Unless otherwise noted, data presented for each country represent primary copper metal output, whether produced by thermal or electrowinning. To the extent possible, refined copper produced from imported blister or electrolytic anode copper has been excluded.

[2]Copper content of impure bars and electrolytic copper.

[3]Smelter output of domestic and foreign ores, exclusive of that from scrap; production from domestic ores only was as follows in short tons: 1974—1,532,066; 1975—1,374,324; 1976—1,461,256.

[4]Figures presented are total blister and equivalent copper output including that blister subsequently refined in Chile and copper which is produced by electrowinning.

[5]Revised to zero.

[6]Belgium reports a large quantity of refined copper, but this is mainly from imported blister; domestic smelter production is reported output of blister copper from ores.

[7]Reported Norwegian copper output is derived in part from copper-metal matte imported from Canada, and reported Canadian smelter production may also contain this material. Norwegian smelter output from domestic ores was as follows (approximately) in short tons: 1974—6,500; 1975—7,500; 1976—7,600.

[8]Year ending September 30 of that stated.

[9]Data from Tsumeb Corp., Ltd.

[10]Data include refined copper plus exported blister and leach cathodes.

[11]Includes secondary.

Table 44.—Copper: World refinery production by country[1]

(Short tons)

Country	1974	1975	1976[p]
North America:			
Canada[2]	616,329	583,342	562,749
Mexico	75,179	69,610	83,134
United States	1,654,658	1,443,378	1,539,308
South America:			
Argentina[e]	90	90	90
Brazil[2]	41,120	31,750	34,280
Chile	593,150	589,960	696,700
Peru	42,940	58,390	154,451
Europe:			
Albania[e]	8,540	8,540	8,800
Austria	29,446	29,686	31,514
Belgium[3]	[r]428,036	393,551	502,796
Bulgaria[e]	52,900	52,900	52,900
Czechoslovakia[2]	22,981	25,159	26,455
Finland	42,193	39,423	42,052
France	24,866	21,491	21,269
Germany, East[e]	50,700	52,900	52,900
Germany, West	466,896	465,397	492,271
Hungary[e] [2]	19,000	19,000	19,000
Norway	27,345	21,688	18,543
Poland	215,000	274,500	297,600
Portugal	2,793	1,365	1,270
Romania[e]	[r]37,500	[r]41,000	44,600
Spain	160,055	152,833	165,640
Sweden	52,335	54,529	[e]57,800
U.S.S.R.[e]	777,000	800,000	837,800
United Kingdom	76,165	83,226	56,832
Yugoslavia	154,038	136,562	134,027
Africa:			
Rhodesia, Southern[e]	33,000	33,000	33,000
South Africa, Republic of	97,550	95,240	105,050
Zaire[4]	280,617	249,128	72,752
Zambia	746,103	693,518	766,043

Table 44.—Copper: World refinery production by country[1] —Continued

(Short tons)

Country	1974	1975	1976[p]
Asia:			
China, People's Republic of[e]	165,000	165,000	165,000
India	12,976	18,016	27,223
Iran[e]	7,700	7,700	7,700
Japan	1,097,955	902,639	952,783
Korea, North[e]	14,000	14,000	14,000
Korea, Republic of[2]	13,668	23,069	32,780
Taiwan	10,868	9,413	12,853
Turkey	32,630	23,589	17,600
Oceania: Australia	179,082	182,730	177,186
Total	[r]8,362,404	7,867,312	8,318,751

[e]Estimate. [p]Preliminary. [r]Revised.

[1]Unless otherwise noted, data presented for each country represent total primary refined copper (both fire refined and electrolytically refined), including refined from imported crude copper (blister and electrolytic anode).

[2]Includes secondary.

[3]Data include leach cathodes from Zaire, secondary, and alloy material.

[4]Excludes metal content of leach cathodes which are included in Belgian production.

Diatomite

By A. C. Meisinger[1]

U.S. production of processed diatomite in 1976 increased 10% in quantity and 20% in value compared with that of 1975. Filtration, with 60% of domestic demand, continued to be the major use for diatomite during the year. Exports of processed diatomite also increased and represented 24% of domestic production in 1976. Diatomite imports totaled 5,154 tons (a record quantity) in 1976 and were primarily from West Germany.

DOMESTIC PRODUCTION

Production of domestic processed diatomite in 1976 was 631,380 tons valued at nearly $55 million, or increases of 10% in quantity and 20% in value compared with that of 1975.

Production continued to come from five States: California, Kansas, Nevada, Oregon, and Washington, where companies operated 16 mine and plant facilities. Domestic producers in 1976 were Johns-Manville Sales Corp., with operations at Lompoc, Calif.; Grefco, Inc., Lompoc, Calif., and Mina, Nev.; Excel-Minerals Co., Taft, Calif.; Airox Earth Resources, Inc., Santa Maria, Calif.; NL Industries, Inc., Wallace, Kans.; Eagle-Picher Industries, Inc., Sparks and Lovelock, Nev.; Cyprus Mines Corp., Fernley, Nev.; American Fossil, Inc., Christmas Valley, Oreg.; and Inorganic Specialities Div., Witco Chemical Corp., Quincy, Wash.

Witco Chemical Corp. revealed plans in early 1976 to construct a new plant to manufacture diatomite products by 1978. Site of the plant was not announced by the company.

Table 1.—Diatomite sold or used by producers in the United States

	1972	1973	1974	1975	1976
Domestic production (sales) short tons	576,089	608,906	664,303	572,582	631,380
Average value per ton	$65.19	$59.26	$76.31	$80.01	$87.08

CONSUMPTION AND USES

Compared with 1975 consumption, all reported end uses of diatomite increased in quantity with the exception of silicate compounds and additives. Filtration continued to be the major end use with 60% of domestic demand for diatomite in 1976, followed by fillers, lightweight aggregates, and insulation. Miscellaneous end uses included abrasives, absorbents, additives, admixtures, carriers, and coatings for numerous applications, primarily in the agricultural, chemical, construction, and paint industries.

[1]Industry economist, Division of Nonmetallic Minerals.

Table 2.—Domestic consumption of diatomite, by principal use

(Percent of total consumption)

Use	1972	1973	1974	1975	1976
Filtration	58	61	60	60	60
Fillers	W	W	W	W	W
Insulation	4	4	5	4	5
Miscellaneous	38	35	35	36	35

W Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous."

PRICES

The weighted average price per ton of processed diatomite sold by producers was $87.08, an increase of 9% compared with the 1975 price of $80.01. Price increases were substantial for diatomite used in filtration and fillers (table 3) in 1976. Average prices per ton for diatomite used as abrasives and lightweight aggregates also increased compared with 1975 prices. The only major end use for diatomite that did not increase in average price in 1976 was insulation.

Table 3.—Average annual value per ton of diatomite, by use

Use	1975	1976
Filtration	$91.73	$99.34
Insulation	62.61	62.36
Abrasives	145.56	146.04
Fillers	79.66	92.44
Lightweight aggregate	52.69	55.87
Miscellaneous	45.63	48.10
Weighted average	80.01	87.08

FOREIGN TRADE

The quantity and value of U.S. exports of processed diatomite increased 1% and 11% respectively, compared with those of 1975. The quantity exported (149,200 tons) represented 24% of domestic production (631,380 tons) in 1976, or 2% less than in 1975. Principal countries of destination were Canada, 41,675 tons; Japan, 15,083 tons; West Germany, 14,845 tons; the United Kingdom, 14,386 tons; and Australia, 12,002 tons. The average value of exports was $113.64 per ton, compared with $104.18 in 1975. Diatomite imports totaled 5,154 tons, of which 96% came from West Germany. The 1976 import total was a record quantity and exceeded by 34.5% the previous record quantity imported in 1975.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1974	186	17,541
1975	147	15,314
1976	149	16,932

Table 5.—Diatomite: World production, by country

(Short tons)

Country	1974	1975	1976[p]
North America:			
Canada[e]	550	550	550
Costa Rica	[r] [e]1,100	[r] [e]1,100	790
Mexico	26,048	25,048	28,984
United States	664,303	573,000	631,000
South America:			
Argentina	[r]18,815	16,535	[e]17,000
Brazil	1,208	6,548	[e]6,600
Chile	2,524	205	364
Colombia	606	[r] [e]660	[e]660
Peru	[r] [e]8,800	14,000	19,003
Europe:			
Austria	2,189	1,731	2,075
Denmark:			
Diatomite[e]	22,000	23,000	23,000
Moler[e]	240,000	250,000	250,000
France[e]	230,000	230,000	230,000
Germany, West (marketable)	[r]56,628	60,219	[e]61,000
Iceland[1]	[e]24,800	[e]24,800	25,021
Italy	34,960	[r] [e]35,000	[e]35,000
Portugal	2,090	2,304	3,472
Romania[e]	44,000	44,000	44,000
Spain[e]	22,000	22,000	22,000
Sweden	624	466	[e]440
U.S.S.R.[e]	440,000	450,000	460,000
United Kingdom	4,409	3,858	[e]3,800
Africa:			
Algeria	8,800	11,000	16,500
Egypt	1,764	454	360
Kenya	1,827	1,983	2,941
South Africa, Republic of	866	715	682
Asia: Korea, Republic of	12,884	21,258	14,862
Oceania:			
Australia	[r]8,199	6,110	[e]1,300
New Zealand	5,024	3,368	3,300
Total	1,887,018	1,829,912	1,904,704

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Exports.

Feldspar, Nepheline Syenite and Aplite

By Michael J. Potter[1]

Feldspar production in 1976 increased by 10% compared to 1975. Sales to the glass industry were unusually high during the first half of 1976. However, the electrical porcelain industry, although not a large consumer of feldspar, was plagued by a series of lengthy strikes. No spot shortages of feldspar, including potash feldspar, occurred during the year.

The feldspar industry continued to face some difficult factors. Possible stricter controls on land use could make new mining permits very difficult to get. Other situations to be faced are long-range goals to strictly regulate waste water discharges and air emissions, rising costs of mining machinery and milling equipment, and enormous construction costs.[2]

Legislation and Government Programs.—According to provisions of the Tax Reform Act of 1969, which continued in force throughout 1976, the depletion rate allowed on feldspar production (both domestic and foreign operations) was 14%.

Table 1.—Salient feldspar statistics

		1972	1973	1974	1975	1976
United States:						
Sold or used by producers[1]	short tons	746,212	791,900	762,723	669,898	739,684
Value	thousands	$10,633	$12,830	$11,396	$11,728	$17,531
Exports	short tons	5,275	9,554	18,319	9,543	6,144
Value	thousands	$184	$466	$662	$507	$352
Imports for consumption	short tons	1,132	367	92	290	93
Value	thousands	$43	$26	$4	$23	$18
Consumption, apparent[2]	short tons	742,069	782,713	744,496	660,645	733,633
World production	thousand short tons	2,994	3,050	[r]3,319	[r]2,893	2,850

[r]Revised.
[1]Includes hand-cobbed feldspar, flotation-concentrate feldspar, and feldspar in feldspar-silica mixtures.
[2]Measured by quantity sold or used plus imports.

FELDSPAR

DOMESTIC PRODUCTION

The 1976 domestic output of feldspar ready to be put into final form for use (that is, the total quantity of hand-cobbed feldspar, flotation-concentrate feldspar, and feldspar content of feldspar-silica mixtures) was 10% higher in tonnage than in 1975. The value for the 1976 output also increased; the values for 1976 in table 2 represent a more highly refined product and are not comparable to previous years. Actual market prices for most types of feldspar increased 6% compared with those of 1975.[3]

Feldspar was mined in 10 States; North Carolina led, followed in descending order by Connecticut, Georgia, California, Okla-

[1]Physical scientist, Division of Nonmetallic Minerals.
[2]Rogers, C., Jr. Feldspar. Min. Eng, v. 29, No. 3, March 1977, p. 59.
[3]Work cited in footnote 2.

homa, South Dakota, Arizona, Wyoming, Maine, and Colorado. The combined outputs of the first four States named amounted to 93% of the U.S. total.

Most of the feldspar used in glassmaking is ground no finer than 20 mesh, and substantial tonnages of feldspathic sands (feldspar-silica mixtures) enter into glass furnace feeds with no further reduction in particle size. Feldspar to be used in ceramic and filler applications is usually pulverized to minus 200 mesh or finer. In 1976, 14 U.S. companies operating 16 plants produced feldspar in 10 States for shipment to destinations in at least 21 States, Puerto Rico, Canada, and Mexico. North Carolina had seven plants, and California had two. Arizona, Connecticut, Georgia, Maine, South Carolina, South Dakota, and Wyoming each had one plant. A change at one company took place as Sobin Chemicals, Inc., became part of IMC Chemical Group, Inc.

Table 2.—Feldspar sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Hand-cobbed		Flotation concentrate		Feldspar-silica mixtures[1]		Total[2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1972	39	653	535	7,354	172	2,627	746	10,633
1973	53	636	546	9,789	193	2,406	792	12,830
1974	46	412	580	8,784	137	2,199	763	11,396
1975	17	274	531	9,260	122	2,193	670	11,728
1976	28	321	601	13,606	111	3,603	740	17,531

[1]Feldspar content.
[2]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

In 1976 there was as usual no significant consumption of feldspar in the raw, unprocessed state in which it is taken from the mine. The majority of users acquired their supplies already ground and sized either by the primary producers or by merchant grinders, although some manufacturers of pottery, soaps, and enamels continued their custom of purchasing crude feldspar for grinding to their preferred specifications in their own mills. The Bureau of Mines canvass of producers and merchant grinders does not provide information concerning the end use distribution of the material handled in this way. It should be noted that a substantial portion of the material classified as feldspar-silica mixtures serves in glassmaking without additional processing.

The 1976 end use distribution of feldspar in the United States indicated that 67% of the total was consumed in glassmaking and 30% was used in pottery. The remaining 3% was used in a diversity of applications, including glazes, enamels, soaps, abrasives, sanitary ware, rubber products, and electrical insulators. The end use data in table 3 for 1976 represent more comprehensive canvass coverage than in 1975.

Table 3.—Feldspar sold by producers, by use

Use	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Hand-cobbed:				
Glass	100	$4	100	$4
Pottery	11,899	405	W	W
Other	4,811	175	26,903	925
Total	16,810	584	27,003	929
Flotation concentrate:				
Glass	254,141	4,733	401,899	8,474
Pottery	172,999	4,806	180,200	4,827
Other	20,019	661	731	13
Total	447,159	10,200	582,830	13,314
Feldspar-silica mixture:[1]				
Glass	24,156	266	89,679	2,911
Pottery	25,870	430	W	W
Other	27,582	806	31,301	1,232
Total	77,608	1,502	120,980	4,143
Total:				
Glass	278,397	5,003	491,678	11,389
Pottery	210,768	5,641	221,740	6,102
Other[2]	52,412	1,642	17,395	895
Total	541,577	12,286	730,813	18,386

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1]Feldspar content.
[2]Includes soaps, abrasives, sanitary ware, rubber, and electrical insulators; totals for "Quantity" and "Value" for 1976 do not correspond to the sums of the subtotals of the three "Other" categories above.

PRICES

Engineering and Mining Journal, December 1976, listed the following prices for feldspar, per short ton, f.o.b. mine or mill, carload lots, bulk, depending on grade (prices were generally about $1 to $8 per ton higher than the corresponding quotations of the preceding year):

North Carolina:	
20 mesh, flotation	$18.75
40 mesh, flotation	$27.50- 29.00
200 mesh, flotation	28.75- 41.00
Georgia:	
40 mesh, granular	27.50
200 mesh	40.00
Connecticut:	
20 mesh, granular	22.50
200 mesh	28.00- 30.00

Feldspar prices were quoted by Industrial Minerals (London), December 1976, as follows (converted from pounds sterling per long ton to dollars per short ton):

Ceramic grade, powder, 200 mesh, bagged, ex-store	$50-$54
Sand, 2-3 millimeters, ceramic and/or glass grade, c.i.f. main European port	29- 39

No explanation was offered for the fact that the ceramic-grade quotations were about 17% lower than their 1975 counterparts, while those for ceramic and/or glass material were 26% lower.

FOREIGN TRADE

In 1976, U.S. exports classified as feldspar, leucite, and nepheline syenite (but presumably all or mostly feldspar) amounted to 6,144 tons valued at $352,492, which was approximately two-thirds the tonnage reported in 1975 and about one-half the value. Chief recipients of the exported material were Canada, 58%; Mexico, 19%; and Venezuela, 12%. The remaining 11% was shared by nine other countries.

U.S. imports for consumption of feldspar in 1976 were lower than in 1975 and amounted to only a small fraction of the quantity exported (2% of the tonnage, 5% of the total value). In addition to feldspar and nepheline syenite, U.S. imports in 1976 included 1,018 tons of material, probably feldspathic in nature, that was classified as "Other mineral fluxes, crushed" with a total value of $197,959.

The tariff schedule in force throughout 1976 provided for a 3-1/2% ad valorem duty on ground feldspar; imports of unground feldspar were admitted duty-free.

Table 4.—U.S. imports for consumption of feldspar

Country	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Crude:				
Canada	--	--	93	$17,614
South Africa, Republic of	[1]209	$17,138	--	--
Total	209	17,138	93	17,614
Ground, crushed, or pulverized:				
Sweden	79	5,800	--	--
United Kingdom	2	450	--	--
Total	81	6,250	--	--

[1]Adjusted by the Bureau of Mines.

WORLD REVIEW

South Africa, Republic of.—Pegmin (Pty) Ltd. was to acquire all the base mineral claims, surface permits, mining, crushing, and milling plant, stores, buildings, vehicles, and raw materials of South African Feldspar (Pty) Ltd. (SAF). Pegmin is a wholly owned subsidiary of Rand London Corp. Ltd. SAF is South Africa's largest feldspar producer and, along with Pegmin, has activities concentrated in the Phalaborwa district. The payment for the purchase was to total some $1 million.[4]

Spain.—Detailed discussions of Spain's industrial minerals, including feldspar, were featured in a journal article.[5]

Sri Lanka.—A series of mineral exploration programs involving industrial minerals was being conducted by the Sri Lanka Geological Department. Feldspar exploration was to be in cooperation with the Ceylon Ceramic Corp.[6]

United Kingdom.—Feldspar imports for 1975 amounted to 147,000 tons and came principally from Norway, 56%; Finland, 25%; and Sweden, 11%. In 1974, feldspar imports were 153,000 tons, mainly from Norway, 65%, Finland, 18%; and Sweden 12%. Nepheline syenite imports were 61,000 tons in 1974 and 41,600 tons in 1975 and came from Norway and Canada.[7]

U.S.S.R.—The U.S.S.R., which lacks large, commercially viable bauxite reserves, has done pioneering work in the production of alumina from nepheline and other alumina-containing minerals, which are plentiful in the country. An article in the Soviet foreign trade bimonthly, Soviet Export, stated that production techniques are now used at two aluminum smelters near Leningrad and at an alumina complex in Siberia. In producing alumina from nepheline, the only other raw material said to be required is limestone, with the complete processing cycle yielding alumina, potash, soda, portland cement and metallic gallium.[8]

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[4]Industrial Minerals (London). Feldspar Giant Changes Hands. No. 103, April 1976, p. 13.

[5]Industrial Minerals (London). The Industrial Minerals of Spain. No. 103, April 1976, pp. 15-55.

[6]Industrial Minerals (London). Company News & Mineral Notes. No. 101, February 1976, p. 49.

[7]Industrial Minerals (London). UK 1975 Mineral Imports. No. 102, March 1976, p. 44.

[8]Engineering and Mining Journal. Soviet Alternatives for Alumina Production Said To Be Cheap, Clean, Easy. V. 177, No. 6, June 1976, p. 35.

Table 5.—Feldspar: World production, by country

(Short tons)

Country[1]	1974	1975	1976[p]
North America:			
Guatemala	33,000	[e]33,000	[e]33,000
Mexico	204,262	158,521	80,732
United States	[r]762,723	669,898	739,684
South America:			
Argentina	[r]62,780	64,000	[e]66,000
Brazil	107,246	119,687	120,000
Chile	3,093	421	106
Colombia	31,636	33,000	[e]33,000
Peru	[e]2,800	[r] [e]3,300	4,305
Uruguay	1,937	1,939	1,262
Europe:			
Finland	70,082	75,593	75,192
France	265,414	181,909	[e]182,000
Germany, West	413,194	436,331	331,795
Italy	262,149	204,158	201,287
Norway[2]	185,315	49,557	[e]50,000
Poland[e]	33,000	33,000	33,000
Portugal	32,959	14,506	14,686
Romania[e]	64,000	64,000	64,000
Spain[3]	79,693	95,102	[e]99,000
Sweden	35,234	49,320	[e]55,000
U.S.S.R.[e]	[r]303,000	310,000	310,000
United Kingdom (china stone)[e]	55,000	55,000	55,000
Yugoslavia	61,833	60,129	[e]60,000
Africa:			
Egypt	2,456	--	2,346
Kenya	3,133	1,781	[e]1,800
Malagasy Republic	[4]11	753	[e]770
Mozambique	926	[e]950	[e]950
Nigeria[e]	5,500	5,500	5,500
South Africa, Republic of	43,585	33,460	50,858
Zambia	1,959	1,294	570
Asia:			
Burma	728	840	981
Hong Kong	6,135	2,270	2,534
India	60,071	42,126	58,878
Japan[5]	68,718	43,494	45,434
Korea, Republic of	27,136	22,198	28,889
Pakistan	[r]3,743	2,981	3,299
Philippines	11,293	4,307	16,799
Sri Lanka	859	859	3,526
Thailand	7,714	14,358	13,511
Oceania: Australia	[r]4,569	3,366	[e]4,100
Total	3,318,886	2,892,908	2,849,794

[e]Estimate. [p]Preliminary. [r]Revised.
[1]In addition to the countries listed, the People's Republic of China, Czechoslovakia, Romania, and the Territory of South-West Africa produce feldspar, but available information is inadequate to formulate reliable estimates of output levels.
[2]Described in source as lump feldspar; does not include nepheline syenite as follows in short tons: 1974, [r]214,591; 1975, [r]203,326; 1976, [e]200,000.
[3]Includes pegmatite.
[4]Chiefly labradorite.
[5]In addition, the following quantities of aplite were produced in short tons: 1974, 539,670; 1975, 357,056; 1976, 394,533.

TECHNOLOGY

The Federal Bureau of Mines continued its work on new or improved beneficiation methods with domestic raw ores, including some New Hampshire granites. Included in these granites are potash and soda feldspar, quartz, and biotite. In other Bureau research, work was initiated on recovering alumina from anorthosite (high lime soda feldspar) using the lime-sinter process.

Sobin Chemical's Ceramic & Glass Products Division plant installed horizontal filters to decrease product moisture content at its facility which went onstream in May 1975 at Spruce Pine, N.C. The feldspar concentrate slurry is pumped to an 8-foot-diameter filter for dewatering to 8% moisture. The product is then dried and screened for shipment to customers.[9]

[9]Chemical Processing. Two Horizontal Filters Handle 52,000 Pounds Per Hour. V. 39, No. 11, October 1976, p. 47.

A U.S. and a Japanese patent were awarded on the use of sulfuric acid instead of hydrofluoric acid in the flotation process for separating feldspar from quartz. Pilot results at North Carolina State University's Minerals Research Laboratory at Asheville have indicated that recoveries are not quite as high as with hydrofluoric acid. Also, the ore has to be ground to a finer mesh to effect adequate separation. This could result in a dustier product, a disadvantage in the average glass furnace.[10]

Steps were taken at the Owens-Illinois, Inc., glass container manufacturing plant in Winston-Salem, N.C., to bring about greater fuel efficiency. These fuel-saving steps were brought about by using a new type of oil burner on the melting tanks which improves heat distribution; by bubbling the glass to accelerate melting and better utilize heat input; and by using ample insulation, especially under the melter bottom.[11]

Investigations were made into origins of bubble defects in commercial soda-lime-silica compositions melted in large float and window glass tanks.[12]

Molded insulating fiber glass components are said to be finding broad applicability in such automotive uses as hoodliners, headliners, and various insulations for side cowls, floors, van engines, and bus panels. The insulating material, which is strong, lightweight, and semirigid, provides greater thermal insulating efficiency than heavier weight hardboard or molded plastic products for similar applications.[13]

Major articles on electric melting of glass from the beginnings to the foreseeable future, compiled from The Glass Industry Magazine, were published in book form.[14]

Several research papers were published relating to various types of feldspar.[15]

NEPHELINE SYENITE

Nepheline syenite, a rock of igneous origin with a texture similar to that of granite, consists essentially of mixtures of nephelite with varying proportions of the alkali feldspars. Nepheline syenite found thus far in the United States has been of a quality suitable only for use as crushed stone. Canada, however, has an immense deposit at Blue Mountain, Ontario, from which two firms, Indusmin Ltd., and International Minerals & Chemical Corp. (Canada) Ltd., mine high-grade material that serves advantageously as an alumina-bearing ingredient in furnace feeds for glassmaking, as either a body component or a fluxing agent for ceramics, and increasingly in recent years as a filler for plastics, latex articles, paints, and paper.

Canadian production of nepheline syenite in 1975, the last year for which an estimate is available, totaled approximately 520,000 tons with a value of $8.7 million. This represented a 16% decrease in tonnage and a 6% decrease in value compared with that of 1974. The quantity exported to the United States in 1976 was back up to the 500,000-ton level.

Other than Canada, only two countries produce significant quantities of nepheline syenite—Norway, with 345,000 tons in 1975 and 297,000 tons in 1976, and the U.S.S.R. where, although production figures are not released, the mineral is known to serve the customary applications of the glass and ceramics industries and also to be a major source of cell-feed alumina for electrolytic aluminum plants.

The price range quoted for imported nepheline syenite in Ceramic Industry Magazine, January 1977, was from $13.00 to $31.45 per ton, depending upon grade, purity, grind, packaging, transportation, quantity sold, and other factors. Industrial Minerals (London), December 1976, quoted price ranges for Norwegian nepheline syenite, c.i.f. main European port (with a minor degree of uncertainty because of the floating sterling-dollar exchange rate), as follows:

Glass grade, 32 mesh (Tyler), bulk, per short ton	$34
Ceramic grade, 325 mesh (Tyler), bagged, per short ton	51

Prices for Canadian material were listed as "nominal."

[10] Work cited in footnote 2.

[11] Svec, J. J. Glass Furnace Modifications Save Fuel. Ceramic Industry, v. 106, No. 4, April 1976, p. 32.

[12] Swarts, E. L. and R. E. Grimm. Bubble Defects in Flat Glass From Large Tanks. Am. Ceram. Soc. Bull, v. 55, No. 8, August 1976, pp. 705-710.

[13] Materials Engineering. Molded Fiber Glass Cuts Noise, Heat and Weight. V. 84, No. 5, November 1976, p. 25.

[14] Pincus, A. G., and G. M. Diken. Electric Melting in The Glass Industry. Books For Industry, Inc., New York, 1976.

[15] Basu, A., and C. J. Vitaliano. Sanidine From the Mesa Falls Tuff, Ashton, Idaho. Am. Mineralogist., v. 61, Nos. 5-6, May-June 1976, pp. 405-408.

Collerson, K. D. Composition and Structural State of Alkalai Feldspars From High-grade Metamorphic Rocks, Central Australia. Am. Mineralogist., v. 61, Nos. 3-4, March-April 1976, pp. 200-211.

La Iglesia, A., J. L. Martin-Vivaldi, Jr. and F. Lopez Aguayo. Kaolinite Crystallization at Room Temperature by Homogeneous Precipitation—III: Hydrolysis of Feldspars. Clays and Clay Minerals., v. 24, No. 1, February 1976, pp. 36-42.

Table 6.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	4,605	$79	505,028	$7,558
1975	6,275	98	424,838	6,869
1976	2,112	38	499,135	8,785

APLITE

Aplite is a fine-grained granitic rock containing quartz mixed with varying proportions of soda, lime-soda, or potash feldspars, any or all of which make it potentially useful as a raw material for manufacturing container glass. However, to be made acceptable for that purpose, the material occurring in most deposits must first be processed to eliminate most of the iron-bearing substances it usually contains. Japan, with about 500,000 tons annually, at least through 1974, is the world's foremost producer.

Aplite of glassmaking quality was produced in the United States in 1976 only from two open pit operations in central Virginia. The Feldspar Corp. mined aplite near Montpelier, Hanover County, and treated the material by wet-grinding, classification, and gravity separation, followed by dewatering, drying, and high-intensity magnetic separation to eliminate iron minerals. IMC Chemical Group, Inc. (formerly Sobin Chemicals, Inc.) operated an aplite mine near Piney River, Nelson County, and removed iron from the dry-ground ore by a high-intensity magnetic process.

Specific annual data on domestic aplite production, sales, and value have not been released for publication since 1962, when the output amounted to 140,000 tons, valued at $0.9 million. Domestic production in 1976 declined slightly in tonnage compared with that of 1975.

Aplite prices are not commonly quoted in trade journals, but the product traditionally commands a somewhat lower per ton price than feldspar. Prices of $15.25 per ton for low-iron material, f.o.b. producing point, and ranging downward to $11.50 per ton for grades higher in iron, were mentioned in early 1976.[16]

[16]Rogers, C., Jr. Feldspar, Aplite, and Nepheline Syenite. Min. Eng., v. 28, No. 3, March 1976, pp. 34-35.

Ferroalloys

By Thomas S. Jones [1]

Modest recovery in steel production, led by a strong advance in production of stainless and heat-resisting steel, and an improved level of foundry activity were reflected in trends for domestic ferroalloy production and consumption in 1976. Shipments increased about one-tenth while production declined very slightly. Both were below 2 million short tons for the second consecutive year. Production was up for ferroalloys of silicon and of chromium but down for manganese ferroalloys. Silicon ferroalloys, including silicon metal, continued to be the leading ferroalloy group in both quantity and value of production and shipments, and also attracted the greatest attention for investment by domestic producers. Among the major ferroalloys, significantly higher consumption was recorded for those of silicon, chromium, and nickel; among specialty ferroalloys, for those of boron, phosphorus, and tungsten. Accompanied by instances of excessive inventory holdings by traders, stocks of chromium ferroalloys grew even further while those of manganese ferroalloys declined by about one-fifth. Because stocks were still high worldwide and demand was not strong, downward pressure on prices was evident among major ferroalloys. However, prices of specialty ferroalloys increased, most sharply for ferroalloys of molybdenum and of tungsten.

The net deficit in U.S. foreign trade in ferroalloys grew 21% to just under 1 million tons, as imports increased 13% while exports declined 49%. The value deficit dropped a small amount as average unit value of imports generally decreased. Imports of ferroalloys of manganese and of silicon were both up by about two-fifths, while those of chromium ferroalloys were down about one-fifth. For both manganese and chromium ferroalloys, imports approximately equalled domestic production; imports of 75% ferrosilicon were more than half of production. Leading import sources were again the Republic of South Africa, Japan, and France. Of expansions in productive capacity underway in foreign countries, some of the more significant were in the Republic of South Africa for manganese and chromium ferroalloys and in Mexico for manganese ferroalloys; growth in ferrosilicon capacity was widespread. Substantial increases in

[1]Physical scientist, Division of Ferrous Metals.

Table 1.— Government inventory of ferroalloys, December 31, 1976

(Thousand short tons)

Alloy	National stockpile	Supplemental stockpile	Total[1]
Ferrochromium:			
High-carbon	126	276	403
Low-carbon	128	191	319
Ferrochromium-silicon	26	33	58
Ferrocolumbium (contained columbium)	0.5	--	0.5
Ferromanganese:			
High-carbon	30	570	600
Medium-carbon	29	--	29
Ferromolybdenum (contained molybdenum)	.01	--	.01
Ferrotungsten (contained tungsten)	1	--	1
Silicomanganese	24	--	24

[1]Data may not add to totals shown because of independent rounding.

Table 2.—Ferroalloys produced and shipped from furnaces in the United States[1]

	1975				1976			
	Production		Shipments		Production		Shipments	
	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)
Ferromanganese[2]	575,809	79	556,131	$222,522	482,662	79	494,222	$207,505
Silicomanganese	143,262	66	126,418	53,913	128,917	66	132,364	52,649
Ferrosilicon[3]	790,860	55	709,937	321,470	860,799	57	890,844	409,726
Chromium alloys:								
Ferrochromium:								
High carbon	117,643	67	116,357	78,483	167,125	66	161,757	82,774
Low carbon	53,973	70	43,325	56,489	28,140	69	30,912	39,059
Ferrochromium-silicon	51,992	37	41,306	27,527	54,182	37	50,680	32,620
Other alloys[4]	25,209	48	22,495	15,048	19,800	60	20,195	21,481
Total	248,817	59	223,483	177,547	269,247	60	263,544	175,934
Ferrocolumbium	615	65	481	3,549	1,205	65	933	6,359
Ferrophosphorus	102,896	21	96,006	10,927	110,903	24	92,689	11,173
Other[5]	64,195	XX	55,639	116,809	56,485	XX	50,942	134,322
Grand total	1,926,454	XX	1,768,095	906,737	1,910,218	XX	1,925,538	997,668

XX Not applicable.
[1]Does not include alloys consumed in the making of other ferroalloys.
[2]Includes fused-salt electrolytic low carbon ferromanganese ("massive manganese").
[3]Includes silicon metal, silvery iron, and miscellaneous silicon alloys.
[4]Includes chromium briquets, exothermic chromium additives, other miscellaneous chromium alloys, and chromium metal.
[5]Includes ferroaluminum, ferroboron and other complex boron additive alloys, ferromolybdenum, ferronickel, ferrotitanium, ferrotungsten, ferrovanadium, ferrozirconium, spiegeleisen, and other miscellaneous alloys.

electrical energy costs in many foreign countries that produce ferroalloys, such as the Republic of South Africa and Japan, was a development that might possibly favor U.S. producers in the long run.

New materials for alloying made commercially available by U.S. producers included a complex, rare earth-containing version of magnesium-ferrosilicon for production of compacted-graphite cast iron and, for steelmaking, a vanadium additive termed ferrovanadium carbide.

Detailed information concerning production, trade, and use of specific alloys can be found in the respective chapters on columbium, chromium, manganese, molybdenum, nickel, silicon, tungsten, and vanadium.

Legislation and Government Programs.—Effective May 4, 1976, the U.S. Environmental Protection Agency (EPA) issued a set of national air pollution control standards applicable to electric submerged-arc furnaces and associated dust-handling equipment, construction or modification of which began after October 21, 1974. Production of all the alloys commonly produced in submerged-arc furnaces was covered, excepting ferrophosphorus. The regulations called for in-plant control of furnace emissions. Collection hoods were required that capture all emissions generated within the furnace and all tapping emissions during at least 60% of tapping time. Removal of particulate matter by air pollution control equipment was required to keep discharges into the atmosphere below 0.99 pound per megawatt-hour (lb/MW-hr) for furnaces producing ferrosilicon and silicon metal and below 0.51 lb/MW-hr for furnaces producing manganese and chromium alloys. Producers were also required to continuously monitor the opacity of emissions and to keep comprehensive records of smelting operations.[2]

On October 1, 1976, the Federal Preparedness Agency of the General Services Administration (GSA) announced a new set of stockpile goals as flexible targets under a long-range plan calling for review as required by circumstances. These goals were established by a study of national needs in the event of 3 years of an emergency, with defense and civilian requirements estimated separately. Actual stockpile activities were to be determined annually subject to Congressional and other constraints.

Government inventories of ferroalloys are listed in table 1. Shipments of stockpile excesses during 1976 consisted of 7,721 tons of high-carbon ferromanganese and most of the remaining ferromolybdenum.

[2]U.S. Code of Federal Regulations. Title 40—Protection of Environment; Chapter I—Environmental Protection Agency; Subpart Z—Standards of Performance for Ferroalloy Production Facilities (Sections 60.260-60.266). July 1, 1976, pp. 57-61.

DOMESTIC PRODUCTION

Production and shipments of ferroalloys fell below 2 million tons for the second consecutive year, according to data provided by the firms listed in table 3. The quantities shipped advanced over those in 1975 by 9% at nearly 10% greater value, whereas production volume dropped by 1%. Silicon was again the leading alloy group in domestic production, shipments, and value. Increased production of silicon alloys and chromium alloys, stimulated by recovery in the foundry and stainless steel industries, was not enough to offset a 16% decrease in production of manganese alloys. Product mix was such that The Ferroalloys Association reported consumption of 8.95 billion kilowatt-hours (kW-hr) of electric energy for the year, a 10% increase. Production of high-carbon ferrochromium, 50% ferrosilicon, and especially standard ferromanganese, all large-volume alloys, declined in the last part of the year. Some firms had operating rates as low as 50% to 65% of capacity in the fourth quarter.

Producers continued to concentrate their investments in silicon alloys facilities against a backdrop of plentiful domestic and worldwide supplies of ferrosilicon that included important new sources in nearby Canada. At the Niagara Falls, N.Y., plant of the Airco Alloys division of Airco, Inc., a 36 megavolt-ampere (MVA) furnace with annual capacity of over 40,000 tons of 50% ferrosilicon was brought into service in the second half of the year. Northwest Alloys, Inc., a subsidiary of Aluminum Co. of America, activated a ferrosilicon furnace rated at 18,000 annual tons in the first part of the year at a new plant at Addy, Wash. Initially, the product was to be used mostly for making magnesium, but eventually quantities were to be available for sale. Foote Mineral Co. made major modifications to its furnaces for silvery pig iron at Keokuk, Iowa, an upgrading action which necessitated production curtailments. Ohio Ferro-Alloys Corp. completed startup of all three furnaces at its new silicon metal plant at Montgomery, Ala. New facilities other than those for air pollution control were not involved in the decision by Chromasco Ltd. to start producing ferrosilicon again at the plant of its Chromium Mining & Smelting Corp. division near Memphis, Tenn.

In chromium alloys, Airco took steps to increase the capability of its Charleston, S.C., plant by upgrading a furnace from 40 to 60 MVA. The Satralloy, Inc., division of Satra Corp. activated a 10 MVA furnace at its Steubenville, Ohio, plant in midyear in order to make high-carbon ferrochromium, while Foote Mineral Co. ceased furnace production of special chromium alloys formerly made at its Graham, W.Va., plant, a decision influenced by the cost of complying with environmental regulations.

In other alloys, the number of ferrophosphorus producers remained unchanged as the Tennessee Valley Authority permanently ended production at the end of May, whereas the Electro-Phos Corp., owned by Japanese interests, restarted facilities at Pierce, Fla. which were operated several years ago by the Agrico Chemical Co. division of Continental Oil Co. Teledyne Wah Chang Albany, included in table 3 for the first time, has been producing ferrocolumbium for several years; therefore, 1975 and 1976 figures for ferrocolumbium in table 2 are not directly comparable. An affiliation between producers of specialty alloys that developed during the year was the acquisition by Molycorp, Inc., of just under 50% of the shares of Kawecki-Berylco Industries, Inc.

Expenditures for air pollution control continued to consume a significant portion of investment dollars. International Minerals & Chemical Corp., which is managing construction at Bridgeport, Ala., of the 40 megawatt (MW) ferrosilicon furnace plant of its Tennessee Alloys Co. joint venture with the Allegheny Ludlum Steel division of Allegheny Ludlum Industries, Inc., attributed 24% of project cost to air pollution control facilities.

Table 3.—Producers of ferroalloys in the United States in 1976

Producer	Plant location	Products[1]	Type of furnace
Airco, Inc., Airco Alloys Div.	Calvert City, Ky Charleston, S.C Mobile, Ala Niagara Falls, N.Y	FeCr, FeCrSi, FeMn, FeSi, SiMn.	Electric.
Alabama Alloy Co., Inc	Bessemer, Ala	FeSi	Do.
Aluminum Co. of America, Northwest Alloys, Inc.	Addy, Wash	FeSi	Do.
AMAX Inc. Climax Molybdenum Co. Div.	Langeloth, Pa	FeMo	Metallothermic.

See footnotes at end of table.

Table 3.—Producers of ferroalloys in the United States in 1976 —Continued

Producer	Plant location	Products[1]	Type of furnace
Bethlehem Steel Corp	Johnstown, Pa	FeMn	Blast.
Chromasco Ltd., Chromium Mining & Smelting Corp. Div.	Woodstock, Tenn	FeCr, FeSi	Electric.
Diamond Shamrock Corp., Chemetals Div.	Kingwood, W. Va	FeMn	Fused salt electrolytic.
Engelhard Minerals & Chemicals Corp.:			
Minerals and Chemicals Div	Strasburg, Va	FeV	Metallothermic.
Philipp Brothers Div. Roane Electric Furnace Co., Inc.	Rockwood, Tenn	FeMn, FeSi, SiMn.	Electric.
Foote Mineral Co., Ferroalloys Div.	Cambridge, Ohio; Graham, W. Va; Keokuk, Iowa	FeCrSi, FeSi, FeV, silvery pig iron, other.[2]	Do.
Gulf & Western Industries, Inc. New Jersey Zinc Co.	Palmerton, Pa	Spln	Do.
Hanna Mining Co., The:			
Hanna Nickel Smelting Co	Riddle, Oreg	FeNi, FeSi	Do.
Silicon Div	Wenatchee, Wash	FeSi, Si	Do.
Interlake, Inc., Globe Metallurgical Div.	Beverly, Ohio; Selma, Ala	FeCr, FeCrSi, FeSi, Si, SiMn.	Do.
International Minerals & Chemical Corp. Industrial Minerals Div.			
Tennessee Alloys Co.	Bridgeport, Ala	FeSi	Do.
Tennessee Metallurgical Corp	Kimball, Tenn	FeSi	Do.
Kawecki-Berylco Industries, Inc.:			
National Metallurgical Div	Springfield, Oreg	Si	Do.
Penn Rare Metals Div	Revere, Pa	FeCb	Metallothermic.
Metallurg, Inc., Shieldalloy Corp.	Newfield, N.J	FeAl, FeB, FeCb, FeTi, FeV, other.[2]	Do.
Molycorp, Inc	Washington, Pa	FeB, FeMo, FeW.	Electric and metallothermic.
Ohio Ferro-Alloys Corp	Brilliant, Ohio; Montgomery, Ala; Philo, Ohio; Powhatan Point, Ohio	FeB, FeMn, FeSi, Si, SiMn.	Electric.
Pennzoil Co., Duval Corp.	Sahuarita, Ariz	FeMo	Metallothermic.
Reactive Metals and Alloys Corp	West Pittsburg, Pa	FeTi, other[2]	Electric.
Reading Alloys, Inc	Robesonia, Pa	FeCb, FeV	Metallothermic.
Reynolds Metals Co	Sheffield, Ala	Si	Electric.
Sandgate Corp., Tenn-Tex Alloy Corp. of Houston (leased to Union Carbide Corp.)	Houston, Tex	FeMn, SiMn	Do.
Satra Corp., Satralloy, Inc. Div.	Steubenville, Ohio	FeCr, FeCrSi, FeMn.	Do.
Teledyne, Inc., Teledyne Wah Chang Albany Div.	Albany, Oreg	FeCb	Metallothermic.
Union Carbide Corp., Metals Div.	Alloy, W. Va; Ashtabula, Ohio; Marietta, Ohio; Niagara Falls, N.Y; Portland, Oreg; Sheffield, Ala	FeB, FeCr, FeCrSi, FeMn, FeSi, FeV, FeW, Si, SiMn, other.[2]	Electric.
United States Steel Corp	McKeesport, Pa	FeMn	Blast.
Ferrophosphorus:			
Electro-Phos Corp	Pierce, Fla	FeP	Electric.
FMC Corp., Industrial Chemical Div.	Pocatello, Idaho	FeP	Do.
Mobil Oil Corp., Mobil Chemical Co. Div.	Nichols, Fla	FeP	Do.
Monsanto Co., Monsanto Industrial Chemicals Co.	Columbia, Tenn; Soda Springs, Idaho	FeP	Do.
Occidental Petroleum Corp., Hooker Chemical Div., Hooker Chemicals & Plastics Corp.	Columbia, Tenn	FeP	Do.
Stauffer Chemical Co., Industrial Chemical Div.	Mt. Pleasant, Tenn; Silver Bow, Mont; Tarpon Springs, Fla	FeP	Do.
Tennessee Valley Authority	Muscle Shoals, Ala	FeP	Do.

[1]FeAl, ferroaluminum; FeB, ferroboron; FeCb, ferrocolumbium; FeCr, ferrochromium; FeCrSi, ferrochromium-silicon; FeMn, ferromanganese; FeMo, ferromolybdenum; FeNi, ferronickel; FeP, ferrophosphorus; FeSi, ferrosilicon; FeTi, ferrotitanium; FeV, ferrovanadium; FeW, ferrotungsten; Si, silicon metal; SiMn, silicomanganese; Spln, spiegeleisen.

[2]Includes specialty silicon alloys, zirconium alloys, and miscellaneous ferroalloys.

CONSUMPTION AND USES

Reported consumption increased over that for 1975 for all ferroalloy categories except silicomanganese, ferromolybdenum, and ferrovanadium. According to the usage patterns of the respective ferroalloys, consumption trends generally paralleled modestly increased raw steel production, stronger recovery in iron foundry activity, and nearly 50% greater production of stainless and heat-resisting steels.

The largest ferroalloy consumption component was manganese alloys in carbon steel, within which consumption of medium and low-carbon grades of ferromanganese increased by the highest percentage. For silicomanganese, declines in consumption in carbon and in alloy steel together exceeded the one-third increase in use of this alloy in cast iron. After manganese alloys, silicon alloys were used in greatest quantity in carbon steel, mostly as 50% ferrosilicon. Consumption of this ferrosilicon grade and of other silicon alloys was largest in cast iron, and grew for both alloy groups by about one-third in that end use. Consumption increases of 30% and more were reported for ferroboron each in alloy and in carbon steel, evidencing the trend toward more utilization of the hardening action of boron in such specific applications as bolts. Use of ferrophosphorus was up by a similar amount in carbon steel and by an even greater percentage in cast iron. The Association of American Railroads adopted a 3% phosphorus cast iron as the standard for metal brake shoes on freight cars. Figures for ferrophosphorus do not include the substantial amount consumed in producing vanadium.

Significantly increased production of stainless and heat-resisting steels called forth expected sizable increases in consumption of chromium alloys and of ferronickel, and also similarly raised demand in the stainless category for ferrotitanium and for manganese and silicon alloys. Spread of argon-oxygen decarburization in stainless steelmaking increased the need in ferronickel for both new physical forms and medium-carbon grades. The 80% increase in consumption of ferrotitanium in stainless and heat-resisting steels arose from a combination of greater production and strong automotive industry demand, especially for titanium-containing muffler grade Type 409. Of the remaining ferroalloy groups, consumption rose markedly only for ferrotungsten, for which demand was up 20% in tool steel. Consumption of ferromolybdenum also increased in tool steel, by 26%, but otherwise declined in all steel end uses and overall. The drop in production of high-strength low-alloy steel held back growth in ferrocolumbium con-

Table 4.—Consumption by end use of ferroalloys as additives in the United States in 1976[1]

(Short tons of alloys)

End use	FeMn	SiMn	FeSi	FeTi	FeP	FeB
Steel:						
Carbon	717,192	87,888	135,319	976	12,553	470
Stainless and heat-resisting	14,973	7,737	[2]26,215	2,008	W	24
Other alloy	155,343	34,952	[2]76,964	818	1,327	478
Tool	2,538	29	[2]3,509	W	--	--
Unspecified	724	2,962	5,091	--	--	--
Total steel[3]	890,770	133,568	247,098	3,802	13,880	972
Cast irons	23,179	16,006	406,799	100	6,786	10
Superalloys	565	W	456	455	--	W
Alloys (excluding alloy steels and superalloys)	17,436	3,003	65,088	768	319	50
Miscellaneous and unspecified	2,363	1,951	54,101	273	6,235	2
Total	934,313	154,528	773,542	5,398	27,220	1,034
Percent of 1975	102	96	113	104	168	130

W Withheld to avoid disclosing individual company confidential data; included in "Miscellaneous and unspecified."

[1]FeMn, ferromanganese including spiegeleisen and manganese metal; SiMn, silicomanganese; FeSi, ferrosilicon including silicon metal, silvery pig iron, and inoculant alloys; FeTi, ferrotitanium including other titanium materials; FeP, ferrophosphorus including other phosphorus materials; FeB, ferroboron including other boron materials.

[2]Part included in "Unspecified."

[3]Except for data withheld.

sumption and mainly caused ferrovanadium to show the largest overall percentage decrease in consumption.

In steelmaking, ferroalloy elements were used almost entirely in ferroalloy form except for molybdenum, nickel, and tungsten. Molybdenum oxide was preferred over ferromolybdenum by a 7:1 ratio. The opposite was true in cast iron, wherein consumption of ferromolybdenum dominated over that of the oxide by 4:1. Iron foundries consumed relatively minor amounts of nickel, mostly in forms other than ferronickel.

Table 5.—Consumption by end use of ferroalloys as alloying elements in the United States in 1976[1]

(Short tons of contained elements)

End use	FeCr	FeMo	FeW	FeV	FeCb	FeNi
Steel:						
Carbon	3,163	150	--	486	442	--
Stainless and heat-resisting	169,523	628	34	21	230	21,503
Other alloy	50,535	853	[2]49	[3]2,942	762	7,394
Tool	3,208	378	341	565	(4)	--
Unspecified	W	W	(2)	W	22	--
Total steel[5]	226,429	2,009	424	4,014	1,456	28,897
Cast irons	6,889	1,679	2	56	--	382
Superalloys	7,455	145	45	15	211	175
Alloys (excluding alloy steels and superalloys)	4,794	462	45	[3]9	25	1,755
Miscellaneous and unspecified	2,692	73	--	50	3	1
Total	248,259	4,368	516	4,144	1,695	31,210
Percent of 1975	123	96	114	88	101	123

W Withheld to avoid disclosing individual company confidential data; included in "Miscellaneous and unspecified."

[1]FeCr, ferrochromium including other chromium ferroalloys and chromium metal; FeMo, ferromolybdenum including calcium molybdate; FeW, ferrotungsten including melting base self-reducing tungsten; FeV, ferrovanadium including other vanadium-carbon-iron ferroalloys; FeCb, ferrocolumbium including small amount of ferrotantalum-columbium, tantalum metal, and other columbium-tantalum materials; FeNi, ferronickel.

[2]"Unspecified" included with "Other alloy."

[3]Part included in "Miscellaneous and unspecified."

[4]Included with "Unspecified."

[5]With minor exceptions as denoted by W and footnote 3 where applicable.

STOCKS

Yearend industry stocks of manganese alloys decreased 19%, those of silicon alloys were little changed, and those of chromium alloys increased 17%. The most significant change in manganese alloys was a 38% decrease in consumer stocks of high-carbon ferromanganese, of which stocks declined almost continuously during 1976. Stocks of chromium alloys gained mainly because of a 45% increase in producer stocks of high-carbon ferrochromium, holdings of which peaked in September. Consumer stocks of chromium alloys increased only slightly but still represented a record total for the second consecutive year. For most major ferroalloys, industry inventories at yearend constituted a 2- to 3-month supply; however, stocks of high-carbon ferrochromium and silicomanganese amounted to about a 5-month supply at prevailing rates of consumption.

PRICES

Producer prices of major ferroalloys declined except for a few advances that were in keeping with the general level of inflation. Declines were attributable to the combined effects of large inventories, only moderate demand from major consuming sectors, competition among domestic producers, and competition between domestic and imported alloys. Strong downward pressure on price was most evident for both high- and low-carbon grades of chromium alloys. Pricing actions in chromium alloys included the offering by Union Carbide Corp. of 3-year long-term contracts containing future discounts. Standard ferromanganese decreased 3% in price in January; further market weakness was signified by gradual declines in price for imported ferromanganese, which at yearend for delivery in 1977 was more than $50 per ton below

Table 6.—Stocks of ferroalloys held by producers and consumers in the United States at yearend

(Short tons)

	Producer		Consumer		Total	
	1975 (gross weight)	1976 (gross weight)	1975 (gross weight)	1976 (gross weight)	1975 (gross weight)	1976 (gross weight)
Manganese ferroalloys[1]	136,929	154,820	324,046	218,164	460,975	372,984
Silicon alloys[2]	132,702	117,760	r79,407	68,130	212,109	185,890
Ferrochromium[3]	74,387	96,116	67,820	69,948	142,207	166,064
Ferroboron[4]	561	485	218	246	779	731
Ferrophosphorus[5]	39,763	62,162	4,174	13,624	43,937	75,786
Ferrotitanium[6]	W	W	2,043	1,232	2,043	1,232
Total[7]	384,342	431,343	r477,708	371,344	862,050	802,687
	1975 (contained element)	1976 (contained element)	1975 (contained element)	1976 (contained element)	1975 (contained element)	1976 (contained element)
Ferrocolumbium[8]	549	561	551	481	1,100	1,042
Ferromolybdenum[9]	878	317	708	750	1,586	1,067
Ferronickel	W	W	r11,210	6,839	11,210	6,839
Ferrotungsten[10]	W	W	116	136	116	136
Ferrovanadium[11]	542	924	868	924	1,410	1,848
Total	1,969	1,802	r13,453	9,130	15,422	10,932

rRevised. W Withheld to avoid disclosing individual company confidential data.
[1]Includes ferromanganese, silicomanganese, and manganese metal.
[2]Includes ferrosilicon, miscellaneous silicon alloys, silicon metal, and silvery pig iron in 1975.
[3]Includes other chromium alloys and chromium metal.
[4]Consumer totals include other boron materials.
[5]Consumer totals include other phosphorus materials.
[6]Consumer totals include other titanium materials.
[7]Silvery pig iron not included in 1976.
[8]Consumer totals include small amount of ferrotantalum-columbium, tantalum metal, and other columbium-tantalum materials.
[9]Consumer totals include calcium molybdate.
[10]Consumer totals include melting base self-reducing tungsten.
[11]Includes other vanadium-iron-carbon ferroalloys.

producer price. A midyear price increase of about 6% for the more common silicon alloys held for 50% ferrosilicon but within a few weeks was nearly completely retracted for the 75% grade.

Prices of specialty ferroalloys increased, by contrast, by 8% to 29%. In ferronickel, competition between domestic and foreign alloy and between ferronickel and alternate forms of primary nickel led to a succession of pricing moves, the net effect of which about equalled an 8% October list price increase. Prices of ferrocolumbium (spot low-alloy) and ferrovanadium both increased 10% in July. A rapid rise in concentrate prices contributed to a two-step increase of 19% in the price of ferrotungsten. Ferromolybdenum prices increased an even larger amount, by 29%, as a consequence of both worldwide demand and cost of recent investments in molybdenum facilities.

Representative producer prices are given in the following table:

Alloy	Price in 1976[1]	
	Beginning	Yearend
Charge chromium (66% to 70%)	$0.50	$0.43
Low-carbon ferrochromium, 0.02% maximum carbon ("Simplex")	.92	.85
Standard 78% ferromanganese, per long ton of alloy	440.00	425.00
Ferromolybdenum, lump	3.44	4.43
Ferronickel	2.16	2.34
Ferrosilicon, 50%	.325	.345
Ferrosilicon, 75%	.365	.37

[1]Per pound contained, except as noted otherwise.

Source: Metals Week.

FOREIGN TRADE

Imports of ferroalloys were nearly 21 times as great as exports at a value over 8 times as much. The net trade deficit was slightly less than a million tons, a 21% increase over that of 1975, and the value deficit decreased 2% to just under $400 million. For quantity by alloy group, the deficit increased the most for manganese alloys, by nearly half again as much as in 1975, while that for silicon alloys almost tripled, for the biggest percentage increase.

Exports declined 49% largely because of sizable decreases in exports of ferromanganese and ferrosilicon. Value of exports fell off much less, however, as average unit value rose 76% because relatively high-value specialty alloys accounted for a larger share than in 1975. Ferrochromium led in export volume, while the unclassified group led in value. Ferrocerium was by far exported in the smallest quantity but was shipped to the largest number of countries. Of more than 50 countries to which ferroalloys were exported, chief recipients were Canada (for roughly two-fifths of both quantity and value), Japan, the Netherlands, Sweden, West Germany, and Brazil.

Imports of ferroalloys increased 13% to a total of over a million tons. The most significant changes were a 37% rise in imports of manganese alloys and a 20% decrease in imports of chromium alloys. Manganese alloys accounted for 60% of all ferroalloy imports, with import volume of high-carbon ferromanganese more than twice that of high-carbon ferrochromium, the alloy imported in next largest quantity. Imports of high-carbon ferromanganese and of silicomanganese were both considerably increased and those of medium-carbon ferromanganese doubled, while the small amount of low-carbon ferromanganese imported dropped 39%. By contrast, in chromium alloys imports of the low-carbon grade slightly increased at the same time that those of high-carbon ferrochromium reversed the previous year's performance and decreased about one-third. Imports of ferrosilicon were up by 40%, the largest percentage increase of any alloy group, chiefly because of a doubling in import volume of alloys with 8% to 60% silicon. For alloys in this range, average silicon content rose to 44.3%, signifying that the alloy mainly imported in larger quantity was 50% ferrosilicon.

Value of ferroalloy imports was slightly less than in 1975 as average unit value decreased universally for manganese, silicon, and chromium alloys and by 14% for all ferroalloys. Alloys of manganese and of chromium accounted for about 70% of total value of imports. For these two alloy groups, declines in average unit value ranged from as low as 2% for ferrochromium-silicon to as much as 25% for high-carbon ferrochromium. Average chromium content of high-carbon ferrochromium dropped 1.4% to 60.0%. Silicon alloys declined in unit value the most, by one-third for the entire group and by 39% for alloys containing 8% to 60% silicon.

Ferronickel, which accounted for most of the remaining 6% of alloy imports, was down 14% in volume at a 24% increase in unit value. The "Other ferroalloys" category remained insignificant as a percent of total volume but advanced as a group to 4% of total value.

Table 7.—U.S. exports of ferroalloys

Alloy	1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ferrocerium and alloys	96	$503	50	$300	60	$335
Ferrochromium	7,245	3,765	13,218	9,075	13,563	8,785
Ferromanganese	7,011	2,204	32,487	10,743	6,789	3,462
Ferromolybdenum	2,047	7,094	1,121	4,798	1,798	9,447
Ferrophosphorus	3,677	408	437	57	1,636	153
Ferrosilicon	6,575	3,338	39,712	15,732	12,416	7,449
Ferrotungsten	10	215	17	137	--	--
Ferrovanadium	1,335	7,863	1,018	7,952	1,211	9,180
Ferroalloys, n.e.c	18,172	12,186	8,970	9,886	6,687	13,121
Spiegeleisen	547	80	335	208	5,471	901
Total[1]	46,715	37,656	97,365	58,888	49,631	52,833

[1]Data for spiegeleisen, added beginning with figures for 1973, are reflected in totals from that year on.

Imports of ferroalloys and ferroalloy metals were received from over 30 countries, with about one-third of the total each coming from Western Europe and Africa. Asia plus Oceania supplied one-fifth, while the contribution of countries in the Western Hemisphere, chiefly Brazil, Canada, and the Dominican Republic, grew to 12% of the total. Main import sources were mostly the same as in 1975, but with some changes in relative importance. The three leading supplying countries were again the Republic of South Africa ($93 million and 283,000 tons), Japan ($77 million and 162,000 tons), and France ($51 million and 137,000 tons). Because of the relatively high unit value of ferronickel, the Dominican Republic ($47 million and 30,000 tons) was next in value of

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1975 Gross weight (short tons)	1975 Content (short tons)	1975 Value (thousands)	1976 Gross weight (short tons)	1976 Content (short tons)	1976 Value (thousands)
Manganese alloys:						
Ferromanganese containing less than 1% carbon	2,786	2,355	$2,496	1,704	1,461	$1,195
Ferromanganese containing over 1% and less than 4% carbon	34,195	27,893	19,841	73,903	60,025	34,577
Ferromanganese containing 4% or more carbon	360,231	276,402	106,044	461,802	355,947	128,926
Ferrosilicon-manganese (Mn content)	54,723	35,156	22,989	80,118	53,693	24,549
Total manganese alloys	451,935	341,806	151,370	617,527	471,126	189,247
Ferrosilicon:						
8%-60% silicon	15,329	6,182	9,010	31,575	13,983	11,368
60%-80% silicon	54,026	40,265	32,000	66,205	49,238	28,014
80%-90% silicon	825	682	764	160	132	117
Over 90% silicon	257	236	176	836	771	309
Total ferrosilicon	70,437	47,365	41,950	98,776	64,124	39,808
Chromium alloys:						
Ferrochromium containing 3% or more carbon	257,567	158,055	135,041	178,846	107,307	70,035
Ferrochromium containing less than 3% carbon	61,242	39,933	55,589	63,750	42,961	54,784
Ferrosilicon-chromium	4,136	(1)	2,041	15,725	(1)	7,593
Total chromium alloys	322,945	XX	192,671	258,321	XX	132,412
Ferronickel	65,046	(1)	67,818	55,721	(1)	72,161
Other ferroalloys:						
Ferrocerium and other cerium alloys	17	(1)	187	20	(1)	167
Ferromolybdenum	2	2	10	5	4	28
Ferrophosphorous	1	(1)	2	40	(1)	9
Ferrotitanium and ferrosilicon titanium	536	(1)	1,125	899	(1)	1,438
Ferrotungsten and ferrosilicon tungsten	256	209	2,542	521	422	5,451
Ferrovanadium	179	137	1,435	411	259	2,448
Ferrozirconium	548	(1)	416	671	(1)	554
Ferroalloys n.e.c.[2]	1,745	(1)	6,433	1,965	(1)	7,817
Total other ferroalloys	3,284	XX	12,150	4,532	XX	17,912
Total ferroalloys	913,647	XX	465,959	1,034,877	XX	451,540
Metals:						
Manganese	4,378	(1)	4,041	7,082	(1)	5,258
Silicon (96%-99% silicon)[3]	[4]3,980	(1)	[4]3,531	8,257	(1)	5,533
Silicon (99%-99.7% silicon)	3,710	3,654	2,705	1,269	1,255	950
Chromium	1,629	(1)	6,630	2,306	(1)	9,142
Total ferroalloy metals	13,697	XX	16,907	18,914	XX	20,883
Grand total	927,344	XX	482,866	1,053,791	XX	472,423

XX Not applicable.
[1]Not recorded.
[2]Principally ferrocolumbium.
[3]New category effective Jan. 1, 1976, formerly combined with base metal alloys.
[4]Base metal alloys, principally silicon metal (96% to 99% silicon).

imports although only tenth in volume. The descending order of quantity supplied was, for manganese alloys, the Republic of South Africa, France, and Japan; for silicon alloys, Canada, Norway, and France; for chromium alloys, the Republic of South Africa, Southern Rhodesia, and Japan. In ferronickel, the Dominican Republic with over half the total took first position as an import source away from New Caledonia, which supplied most of the rest. In specialty alloys, Brazil was the leading source of ferrocolumbium, France accounted for all imports of ferrozirconium, and about two-thirds of ferrotitanium imports came from the United Kingdom.

Imports in relation to domestic production and reported consumption were greatest for manganese and chromium alloys. In these two groups, imports approximately equalled production and were about three-fifths of consumption. More high-carbon ferromanganese was imported than was produced, while for high-carbon ferrochromium amounts imported and produced were similar. Imports of low-carbon ferrochromium were more than twice the quantity produced and corresponded to four-fifths of consumption. Imports were less of a factor in silicon alloys, for which roughly one-seventh as much was imported as was produced or consumed. However, imports of 75% ferrosilicon came to half or more of totals for both production and consumption.

Under the General System of Preferences (GSP) that became effective January 1, 1976, the Government accorded duty-free status to imports from developing countries of ferromanganese (all grades), silicomanganese, ferrosilicon with 60% to 80% silicon, ferrophosphorus, chromium metal, and silicon metal with 99% to 99.7% silicon.

WORLD REVIEW

Statistics on world production of ferroalloys are summarized in table 9. Facilities for significantly increasing productive capacity during the period, 1976-1978, were being installed for manganese alloys (over 300,000 tons) in Australia, Brazil, India, Mexico, and the Republic of South Africa; for silicon alloys (approaching 200,000 tons) in Australia, Canada, France, Portugal, and Spain; and for chromium alloys (nearly 300,000 tons) in the Republic of South Africa and Turkey.

Argentina.—Ferroalloy production amounted to nearly 49,000 tons, mostly standard ferromanganese and 75% ferrosilicon, plus a small quantity of silicomanganese. Industria Siderúrgica Grassi, S.A., Electrometalúrgica Andina, S.A., and Carbometal, S.A. planned to install a number of relatively small furnaces in the period 1976 to 1978, amounting together to 58 MVA of additional furnace capability.

Australia.—Tasmanian Electrometallurgical Co. Pty. Ltd. (Temco), the sole producer and a subsidiary of Broken Hill Pty. Co. Ltd., began manufacturing 75% ferrosilicon in July at its Bell Bay plant on the northern coast of Tasmania. This new production was from a 45 MVA furnace rated at over 27,000 tons per year. A 27 MVA furnace was expected to begin augmenting ferromanganese and silicomanganese production in 1977. Temco's expansion program was expected to allow exporting in addition to satisfying steel production needs of Broken Hill.

Brazil.—Production increased by 22% to 344,000 tons, a growth rate comparable to that having been experienced for some years by the Brazilian ferroalloy industry but one-fourth below that required to achieve a total of over 1 million tons that had been projected for 1980. Silicomanganese production grew strongly, reflecting the addition of a 24 MVA furnace rated at about 30,000 tons per year by Electrosiderurgica Brasileira S.A. (Sibra) at its plant near Salvador in northeastern Brazil. This furnace plus a ferromanganese furnace with the same power rating were installed with technical and financial aid from Japanese interests. Cia. Paulista de Ferro Ligas announced plans to increase ferromanganese production by about 24,000 tons per year by mid-1977 by setting up a plant near the Urucum manganese deposit in Mato Grosso. These high-phosphorus and high-alkali ores were to be smelted by duplex furnacing. Another new plant for manganese alloys in Mato Grosso was projected by the newly formed Cia. Matogrossense de Ferro-Ligas (Fermat). Initial plans of this partly State-owned company were for five 20 MVA furnaces to be built at Três Lagoas, with production to commence in 1981 using hydropower from Jupiá. Production of ferrocolumbium, which had dropped off in 1975, rose sharply to a new record of 11,000 tons. Additional capacity of over 3,000 tons per year was expected to be available in 1977 from the new mine and smelting operation of Mineração Catalão de Goias S.A.

Canada.—SKW Electro-Metallurgy Canada Ltd. (SKW-Canada) began production at Becancour, Quebec, of ferrosilicon and silicon metal from two furnaces in the third quarter, at a time when other Canadian producers of silicon alloys were operating substantially below capacity. Activation of a third furnace early in 1977 was to make fully available new capacity of 30,000 tons per year of 50% and 75% ferrosilicon from a 30 MW furnace and 25,000 tons per year of silicon from two 20 MW furnaces. Downriver on the St. Lawrence at Beauharnois, Chromasco Ltd. continued phasing in capacity for ferrosilicon, also about 30,000 tons per year.

France.—Cie. Universelle d'Acetylene et d'Electrométallurgie, a part of Société Française d'Electrométallurgie (Sofrem), planned to increase its production of principally 75% ferrosilicon by building a coastal plant at Dunkirk. An Elkem furnace with power-recycling system was to be installed in the new plant for startup in 1978. This would add 55,000 tons per year of ferrosilicon capacity; however, some of the company's older units at Les Clavaux were to be phased out.

Gabon.—A manganese alloys plant was scheduled to be built near Moanda for production beginning in 1981. Planning for the plant was being done by Société Gabonaise des Ferro-Alliages (Sogaferro), a company which associates Cie. Minière de l'Ogooué with the Gabonese Government and firms from six foreign countries. Annual output was projected at 85,000 tons of ferromanganese and 50,000 tons of silicomanganese. Success of the project would be contingent on building both the Grand Poubara Dam to furnish hydropower and the Transgabon railway to carry the finished alloy to the coast for export.

Greece.—Future production of ferronickel on Euboea Island, perhaps by 1980, was indicated by plans of two companies. One project by Soc. Minière et Métallurgique de Larymna S.A. (Larco) at Politika, would add an additional 14,000 tons per year of nickel content to smelter expansion already underway at Larymna on the adjoining mainland. Eleusis Bauxite Mines had under development a program that would produce ferronickel at 10,000 tons per year of nickel content from low-grade lateritic ores. Production of ferrochromium from Greek ore was being studied by the newly formed Hellenic Industrial & Mining Investments Co. (Himic).

Iceland.—Norway's Elkem-Spigerverket A/S (Elkem) assumed Union Carbide's former 45% share in a joint ferrosilicon project with the Government of Iceland. A new company, Islenska Jarnblendifelagid, was organized to replace Icelandic Alloys Ltd. Start of production of 50,000 tons per year of 75% ferrosilicon was delayed 2 years to 1979-80, with Elkem to build the two furnaces planned and to market the product.

India.—Ferroalloy production increased over that in 1975 by 19% to the highest level in 5 years. Ferromanganese production recovered from several years of decline and was to grow further beginning early in 1977 with installation of a furnace for standard ferromanganese in the center of the country at Chandrapur. This unit,

Table 9.—Ferroalloys: World production by furnace type, alloy type, and country

(Thousand short tons)

Country,[1] furnace type,[2] and alloy type[3]	1974	1975	1976[p]
Argentina: Electric furnace:			
Ferromanganese	26	32	26
Silicomanganese	8	6	2
Ferrosilicon	21	19	21
Total	[r]55	57	49
Australia: Electric furnace:			
Ferromanganese	47	[e]52	[e]62
Silicomanganese	24	[e]17	[e]12
Ferrosilicon	10	[e]10	[e]10
Ferrochromium	4	[e]4	--
Total	[r]85	[e]83	[e]84
Austria: Electric furnace, undistributed	7	7	9
Belgium: Electric furnace ferromanganese[4 5]	144	108	93

See footnotes at end of table.

Table 9.—Ferroalloys: World production by furnace type, alloy type, and country —Continued

(Thousand short tons)

Country,[1] furnace type,[2] and alloy type[3]	1974	1975	1976[p]
Brazil: Electric furnace:			
Ferromanganese	88	95	109
Silicomanganese	36	43	77
Ferrosilicon	57	60	50
Ferrochromium	42	58	72
Ferrochromium-silicon	2	3	4
Ferronickel	11	11	11
Other	15	13	21
Total	[r]251	283	344
Bulgaria: Electric furnace, undistributed	50	62	65
Canada: Electric furnace:			
Ferromanganese[6]	[e]100	[e]70	[e]90
Ferrosilicon	105	[e]50	[e]95
Undistributed[7]	[e]68	[e]56	[e]63
Total	273	176	248
Chile: Electric furnace:			
Ferromanganese	9	7	[e]8
Silicomanganese	3	3	[e]3
Ferrosilicon	3	4	[e]4
Other	1	1	[e]1
Total	16	15	[e]16
Colombia: Electric furnace ferrosilicon	([8])	[e]1	[e]1
Czechoslovakia:			
Blast furnace, undistributed	37	31	33
Electric furnace, undistributed	140	146	150
Total	177	177	183
Dominican Republic: Electric furnace ferronickel	88	67	75
Egypt: Electric furnace, undistributed	3	5	[e]5
Finland: Electric furnace ferrochromium	53	44	44
France:			
Blast furnace:			
Spiegeleisen	10	8	--
Ferromanganese	578	463	402
Electric furnace:			
Silicomanganese[9]	9	13	13
Ferrosilicon	261	267	261
Ferrochromium[10]	123	62	112
Other[11]	91	86	100
Total	1,072	899	888
Germany, East:			
Blast furnace spiegeleisen	2	3	--
Electric furnace, undistributed	158	164	166
Total	160	167	166
Germany, West:			
Blast furnace:			
Ferromanganese[5]	353	238	242
Ferrosilicon	130	103	100
Electric furnace, undistributed	312	283	265
Total	795	624	607
Greece: Electric furnace ferronickel[e]	61	61	67
Hungary:			
Blast furnace, undistributed	([12])	--	--
Electric furnace, undistributed	12	11	11
Total	12	11	11
India: Electric furnace:			
Ferromanganese	161	157	186
Silicomanganese	2	[e]2	[e]3
Ferrosilicon	33	44	51
Ferrochromium	17	11	16
Ferrochromium-silicon	2	4	[e]4

See footnotes at end of table.

Table 9.—Ferroalloys: World production by furnace type, alloy type, and country —Continued

(Thousand short tons)

Country,[1] furnace type,[2] and alloy type[3]	1974	1975	1976[p]
India: Electric furnace —Continued			
Other[11]	(8)	(8)	(8)
Total	215	218	260
Italy:			
Blast furnace:			
Spiegeleisen	6	4	3
Ferromanganese	77	64	69
Electric furnace:			
Ferromanganese	11	15	17
Silicomanganese	45	40	46
Ferrosilicon	72	78	86
Ferrochromium	44	49	50
Ferrochromium-silicon	--	(8)	--
Other	19	15	13
Total	274	265	284
Japan: Electric furnace:			
Ferromanganese	688	716	697
Silicomanganese	494	479	411
Ferrosilicon	407	361	345
Ferrochromium	597	536	511
Ferrochromium-silicon	16	28	12
Ferronickel	277	221	219
Other	20	17	18
Total	2,499	2,358	2,213
Korea, Republic of: Electric furnace ferrosilicon	38	23	38
Mexico: Electric furnace:			
Ferromanganese	54	71	68
Silicomanganese	16	18	17
Ferrosilicon	22	20	18
Other	(8)	(8)	e(8)
Total	92	109	103
New Caledonia: Electric furnace ferronickel	205	230	e166
Norway: Electric furnace:			
Ferromanganese	370	374	390
Silicomanganese	207	180	191
Ferrosilicon	342	325	304
Ferrochromium	34	30	30
Ferrochromium-silicon	1	1	1
Other[11]	10	33	9
Total	964	943	925
Peru: Electric furnace ferrosilicon	1	1	e1
Poland:			
Blast furnace:			
Spiegeleisen	9	10	9
Ferromanganese	138	153	128
Electric furnace, undistributed	173	183	180
Total	320	346	317
Portugal:			
Blast furnace, undistributed	1	--	--
Electric furnace, undistributed	12	10	13
Total	13	10	13
Rhodesia, Southern: Electric furnace ferrochromium[e]	200	220	220
South Africa, Republic of:			
Blast furnace and electric furnace, undifferentiated:			
Ferromanganese	400	469	517
Electric furnace:[13]			
Ferrosilicon	98	115	127
Ferrochromium	203	239	263
Other[14]	(8)	(8)	(8)
Total	701	823	907

See footnotes at end of table.

Table 9.—Ferroalloys: World production by furnace type, alloy type, and country —Continued

(Thousand short tons)

Country,[1] furnace type,[2] and alloy type[3]	1974	1975	1976[p]
Spain: Electric furnace:			
Ferromanganese	124	139	146
Silicomanganese	87	94	100
Ferrosilicon	60	61	63
Ferrochromium	24	20	21
Other	([8])	([8])	([8])
Total	295	314	330
Sweden: Electric furnace:			
Silicomanganese	11	10	8
Ferrosilicon	56	55	42
Ferrochromium	111	102	132
Ferrochromium-silicon	20	17	41
Other	3	3	3
Total	201	187	226
Switzerland: Electric furnace ferrosilicon[e]	[r]7	[r]6	6
Taiwan: Electric furnace ferrosilicon	30	26	17
Thailand: Electric furnace:[15]			
Ferromanganese	2	1	2
Ferrosilicon	1	([8])	1
Total	3	1	3
Turkey: Electric furnace ferrochromium[e]	10	10	10
U.S.S.R.:			
Blast furnace:			
Spiegeleisen	118	115	[e]112
Ferromanganese	947	968	[e]937
Other	29	30	[e]31
Electric furnace:[16]			
Ferromanganese[e]	100	90	100
Silicomanganese[e]	28	28	28
Ferrosilicon[e]	330	330	330
Ferrochromium[e]	203	227	231
Ferrochromium-silicon[e]	7	4	6
Other[e] [17]	200	180	195
Total[e]	[e]1,962	[e]1,972	[e]1,970
United Kingdom: Blast furnace:[18]			
Spiegeleisen	9	--	--
Ferromanganese	91	94	136
Total	100	94	136
United States:			
Blast furnace and electric furnace, undifferentiated:			
Ferromanganese	544	576	483
Electric furnace:			
Silicomanganese	196	143	129
Ferrosilicon	932	791	861
Ferrochromium	337	197	195
Ferrochromium-silicon	99	52	54
Other[19]	176	167	188
Total	2,284	1,926	1,910
Uruguay: Electric furnace ferrosilicon	([8])	([8])	[e]([8])
Venezuela: Electric furnace ferrosilicon	2	3	[e]3
Yugoslavia: Electric furnace:			
Ferromanganese	25	34	35
Silicomanganese	19	16	16
Ferrosilicon	115	92	95
Ferrochromium	43	59	61
Ferrochromium-silicon	5	11	11

See footnotes at end of table.

Table 9.—Ferroalloys: World production by furnace type, alloy type, and country —Continued

(Thousand short tons)

Country,[1] furnace type,[2] and alloy type[3]	1974	1975	1976[p]
Yugoslavia: Electric furnace: —Continued			
Other[11]	2	3	3
Total	209	215	221
Grand total	13,927	13,147	13,234
Of which:			
Blast furnace:			
Spiegeleisen[20]	154	140	124
Ferromanganese[20]	2,184	1,980	1,914
Other[21]	159	133	131
Unspecified	38	31	33
Total blast furnace	2,535	2,284	2,202
Electric furnace:			
Ferromanganese[22]	1,949	1,961	2,029
Silicomanganese[22 23]	1,185	1,092	1,056
Ferrosilicon	3,003	2,742	2,830
Ferrochromium[24 25]	2,045	1,868	1,968
Ferrochromium-silicon[24 25]	152	120	133
Ferronickel[25 26]	642	590	538
Other[21 26]	537	518	551
Unspecified[25]	935	927	927
Total electric furnace	10,448	9,818	10,032
Furnace type undifferentiated:			
Ferromanganese only	944	1,045	1,000

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, the People's Republic of China and North Korea are known to produce both blast furnace and electric furnace ferroalloys, but output is not reported and available general information is inadequate for the formulation of reliable estimates of output levels. (Estimates of pig iron production for these countries that appear in the iron and steel chapter of Minerals Yearbook include an inseparable quantity for their ferroalloys production.) Romania is known to produce electric furnace ferroalloys, but output is not reported and no basis is available for estimation.

[2]To the extent possible, ferroalloy production of each country has been separated according to the furnace type from which production is obtained; production derived from metallothermic operations is included with electric furnace production.

[3]To the extent possible, ferroalloy production of each country has been separated so as to show individually the following major types of ferroalloys: Spiegeleisen, ferromanganese, silicomanganese, ferrosilicon, ferrochromium, ferrochromium-silicon and ferronickel. Ferroalloys other than those listed that have been identified specifically in sources, as well as those ferroalloys not identified specifically but which definitely exclude those listed previously in this footnote have been reported as "Other." For countries for which one or more of the individual ferroalloys listed separately in this footnote have been inseparable from some other ferroalloy production has not been subdivided in such deviations are indicated by individual footnote. In instances where ferroalloys owing to the nation's reporting system, sources, and where no basis is available for estimation of individual component ferroalloys, the entry has been reported as "Undistributed."

[4]Electric furnace output, if any, is not reported, and no basis is available for estimation.

[5]Includes spiegeleisen.

[6]Includes silicomanganese.

[7]Includes ferrochromium (1974 only), ferrochromium-silicon (if any), and ferronickel.

[8]Less than 1/2 unit.

[9]Includes silicospiegeleisen.

[10]Includes ferrochromium-silicon.

[11]Includes ferronickel, if any.

[12]Revised to zero (production terminated in 1973).

[13]Ferronickel and silicomanganese also are produced, and ferrochromium-silicon also may be produced, but no basis is available for estimation.

[14]Ferrovanadium only; additional types may be produced, but data are not published and no basis is available for estimation.

[15]Previously reported incorrectly as blast furnace.

[16]Soviet production of electric furnace ferroalloys is not reported; estimates provided are based on crude source material production (reported and estimated) and upon exports of ferroalloys which are reported in detail, by type.

[17]Includes ferronickel.

[18]In addition to blast furnace production reported, other ferroalloys are known to be produced, but data are not published and no basis is available for estimation.

[19]Includes spiegeleisen and ferronickel.

[20]Spiegeleisen for West Germany included with ferromanganese.

[21]Of the totals, the following quantities (in thousand short tons) are specifically identifed as ferrosilicon: 1974—130; 1975—103; 1976—100; the differences between the foregoing figures and the reported totals are not identified in any way, except that they are neither spiegeleisen nor ferromanganese.

[22]Silicomanganese for Canada included with ferromanganese.

[23]Includes silicospiegeleisen for France.

[24]Ferrochromium-silicon for France included with ferrochromium.

[25]Ferrochromium (for 1974 only), ferrochromium-silicon (if any) and ferronickel for Canada included with unspecified.

[26]Ferronickel (if any) for France, India, Norway, the U.S.S.R., the United States and Yugoslavia included with "Other."

being built by Maharashtra Elektrosmelt Ltd. with Norwegian technical assistance, was to be fed local raw materials and, with a rating of about 50,000 tons of alloy per year, would substantially enhance India's export capabilities.

Indonesia.—Ferronickel developments included completion ahead of schedule of a smelter for the 25% alloy by State-owned P.T. Aneka Tambang. Production of ferronickel from this plant at Pomalaa in southeast Sulawesi was expected to grow to over 20,000 tons per year. Japanese interests provided financial backing both for this plant and for another ferronickel project proposed for Gebe Island. Indonesia Nickel Development Corp. (Indeco) was formed to carry out the Gebe Island undertaking, but future of the project was being seriously questioned by the end of the year.

Japan.—Production of ferroalloys again slackened, by 6%, to 2.2 million tons overall, but was still greater than that of the United States. In thousands of tons, main items produced were: Ferromanganese, 697; ferrochromium, 511; silicomanganese, 411; ferrosilicon, 345; and ferronickel, 219. Japan Metals and Chemicals Co. Ltd. brought a 32 MVA ferrosilicon furnace into production near yearend at Wakagawa. Capacity of the furnace was rated at about 19,000 tons per year, but the company's net increase in ferrosilicon capacity will be only half this amount because of the shutting down of several small furnaces. The new furnace became the largest such furnace in Japan to operate on geothermal power, a source of relatively cheap power which became all the more attractive when thermal power costs went up in Japan by 30% or more at midyear. Competitive pressure from imports also was a problem for producers, as six major firms making ferrochromium formed a cartel effective throughout 1976 for setting minimum prices on exports.

Mexico.—Production of manganese alloys began in the fall from the first of two new completely closed 33 MVA furnaces of Cia. Minera Autlán S.A. de C.V., with the second furnace expected to start up early in 1977. These furnaces were installed with Japanese technical assistance in a new plant at Tamós near the Gulf Coast port of Tampico and were to provide annually over 100,000 tons of standard ferromanganese and silicomanganese. As the Tamós plant comes into full operation, adjustments were to be made in the product mix of the company's older plants at Aire Libre and Tezuitlán. The two other Mexican producers, Ferroaleaciones de Mexico, S.A., and Ferralver, S.A., had expansions underway on a smaller scale.

New Caledonia.—Output of ferronickel was to be raised by Société Métallurgique Le Nickel (SLN) to over 100,000 tons per year, nickel content, by 1981. This approximately 20% capacity increase was to be achieved by a combination of mining expansion and smelter improvement beginning in 1977. Upgrading of the Doniambo smelting plant at Noumea was to be directed at ore preparation and calcining rather than installation of additional furnace capacity.

Portugal.—Cia. Portuguesa de Fornos Electricos (CPFE) and Milnorte-Metalurgia do Norte S.A.R.L. (Milnorte) were both reported adding capacity for silicon alloys. Installation by CPFE of a 25 MVA furnace at Canas was estimated to permit production of an additional 15,000 tons per year of ferrosilicon. Two new 24 MVA furnaces were scheduled by Milnorte to begin production of some 20,000 tons per year of ferrosilicon and silicon metal at a Douro River location in northern Portugal.

South Africa, Republic of.—Ferroalloy production registered a 10% advance to over 900,000 tons with a product mix of 4 ferromanganese—2 ferrochromium—1 ferrosilicon.

Chromium.—In December the first of three 30 MVA furnaces began operating at the new Steelpoort plant of Tubatse Ferrochrome (Pty.) Ltd., a joint venture of Union Carbide and South Africa's General Mining and Finance Corp. Ltd. All three furnaces were expected to be operating by the end of 1977, which would bring the plant's capacity for producing charge chromium containing 50% to 55% chromium from plentiful local ores up to 120,000 tons per year. A ferrochromium plant of the same rating being installed at Lydenburg by Johannesburg Consolidated Investment Co. Ltd. with Japanese technical assistance also was expected to start up in 1977. These two plants largely account for a projected doubling of South Africa's ferrochromium capability between 1976 and 1980. However, this possibly overly rapid growth in facilities plus a 60% increase in electric power costs in the past 2 years continued to raise questions about international competitiveness of South African producers.

Manganese.—Modernization and expansion by South African Manganese Amcor Ltd. (Samancor) at its Kookfontein Works at Meyerton included uprating two standard ferromanganese furnaces from 48 to 75 MVA and starting installation of a 75 MVA furnace ordered from Japan, from which production was expected to begin in 1978. Highveld Steel & Vanadium Corp. Ltd. acquired a majority interest in Transalloys (Pty.) Ltd., whose new silicomanganese furnace was slated to be operating by mid-1977.

Spain.—Startup of a new furnace for 75% ferrosilicon at Monzon by Hidro Nitro Española S.A. was now projected for the first part of 1977. Hidro Nitro also was reported planning to build its own hydroelectric facilities on the Yesa Dam. Ferroaleaciones Españolas, S.A. (Fesa), increased its ferrochromium capabilities with activation of a 7.5 MVA furnace at midyear at its Medina del Campo plant. Production of a total of about 3,000 tons per year of specialty ferroalloys was expected to commence about the middle of 1977 by Ferroaleaciones Especiales Asturianas S.A. at a new works at Avilés, using imported feedstock.

Sweden.—Airco's subsidiary at Vargon, Airco Alloys AB, announced its intention to discontinue ferromanganese production and to concentrate on ferrochromium and ferrosilicon. Inability to meet pollution control regulations led to a decision by Avesta Jernwerks AB to stop its captive production of about 25,000 tons of ferrochromium per year.

Turkey.—Built with Japanese technical assistance, the high-carbon ferrochromium plant of State-owned Etibank came into operation near yearend. The two-furnace plant was rated at over 50,000 tons per year.

United Kingdom.—Willan-Wogen Alloys Ltd., with plans for becoming one of the largest European producers of ferrotitanium, was formed by Aurora Holdings Ltd., which had acquired G. L. Willan Ltd., and Wogan Resources Ltd. Capacity of over 3,000 tons per year for largely the 70% alloy was expected to be attained by mid-1977 from the combination of a new induction furnace being installed in a plant at Catcliffe, Sheffield, with already existing facilities at the former Willan plant.

U.S.S.R.—Japan's Tanabe Kakoki was awarded a contract to build six 75 MVA closed furnaces for producing high-carbon ferromanganese. Presumably these units were ordered for installation by about 1980 at the Nikopol manganese complex in the Ukraine, but details were not announced. Other future major expansion was reported scheduled by 1980 at Yermakovsky in western Siberia, where capacity for mostly silicon and chromium alloys has nearly tripled during the last 5 years.

Venezuela.—Hornos Electricos de Venezuela S.A. (Hevensa) installed two 7.5 MVA furnaces of Hungarian manufacture for production of 75% ferrosilicon, ferromanganese, and silicomanganese. Further expansion through addition of a 25 MVA furnace was expected by 1979.

TECHNOLOGY

A single-addition foundry alloy for production of compacted-graphite (CG) cast iron has been developed by joint research between Foote Mineral Co. and the British Cast Iron Research Association. This alloy is based on regular-grade magnesium ferrosilicon and contains controlled amounts of calcium, titanium, and rare earths (about 0.3% cerium). Use of this complex alloy permits reproducible manufacture of cast iron with an interconnected graphite flake morphology. Such a cast iron has a blend of properties intermediate to those of gray and ductile irons. Potential applications suggested for CG cast iron include a number of automotive and machine parts.[3]

Another new alloying material introduced, by Reading Alloys, was a vanadium additive termed ferrovanadium carbide. This additive contains about 68% vanadium and 15% each of carbon and iron and was marketed to compete with other proprietary vanadium additives commonly used by steelmakers. Manufacture of this ferrovanadium carbide is by a patented high-temperature solid-state reduction process whereby powder mixtures, typically of carbon and oxides of iron and vanadium, are reaction-sintered at atmospheric pressure under reducing conditions.[4]

Plasma smelting of ferroalloys, while not yet commercial, continued to interest researchers, particularly with respect to ferrovanadium and ferrochromium. A plasma

[3]Evans, E. R., J. V. Dawson, and M. J. Lalich. Compacted Graphite Cast Irons and Their Production by a Single Alloy Addition. Trans. Am. Foundrymen's Soc., v. 84, 1976, pp. 215-220.

Lalich, M. J. Compacted Graphite Cast Iron. Modern Casting, v. 66, No. 7, July 1976, pp. 50-52.

[4]Perfect, F. H. (assigned to Reading Alloys, Inc., Robesonia, Pa.). Process for Producing Carbide Addition Agents. U. S. Pat. No. 3,982,924, Sept. 28, 1976.

reactor system for ferrovanadium has been developed at Bethlehem Steel Corp.[5] This system was operated at 100 and 500 kW levels, and scale-up to a plant capable of producing over 1 million pounds of vanadium per year was projected. The process entails high-temperature reaction in a plasma between a carbon and a metal oxide with accumulation of product in a molten iron charge held in a receiving crucible. Efficiency of operation was improved by using finely ground coke and vanadium pentoxide prereduced to trioxide. A 50% ferrovanadium was produced in the 500-kW equipment with an energy consumption of about 3 kw-hr/lb of vanadium. Mostly on a theoretical basis, possibilities for applying plasma methods to ferroalloy production were outlined by Westinghouse Electric Corp. researchers, who analyzed the feasibility of making high-carbon ferrochromium from low grade ore.[6]

High-temperature fused-salt electrolysis is used to reduce manganese from ore, by methods developed by Diamond Shamrock for producing "Massive Manganese." This alloy, as made directly from ore, typically contains about 0.14% carbon and 6% iron as major impurity, and is regarded by the Bureau of Mines for statistical purposes as low-carbon ferromanganese. However, a 98% manganese product can be manufactured using a feed of pure manganous oxide obtained from beneficiation of ore. Reaction in the electrolytic cell at about 1,300° C is between carbon anodes and oxide electrolyte to yield a molten metallic product. Fluorspar is used as fluxing agent in the electrolyte, and lime is also added to maintain a balance with acidic constituents of the feed ore.[7]

Introduction of hydrogen into steel by way of ferromanganese and silicomanganese and ways of lowering the hydrogen content of these manganese alloys by heat treatment have been studied. Part of the hydrogen in manganese alloys was found to be dissolved, and part bound as an oxyhydroxide coating which forms when there is contact between the alloy and water in liquid form. The level of hydrogen in ferromanganese could be lowered to that in freshly manufactured alloy by heating to 900° C at atmospheric pressure or to 600° C in a partial vacuum.[8]

International Nickel (U.S.) Inc. announced formation of International Metals Reclamation Company, Inc., to establish and operate a facility near Pittsburgh, Pa., for commercial reclamation of specialty steelmaking waste products. Plans are for the facility to begin processing over 40,000 tons per year of wastes into a nickel-chromium remelt alloy and a zinc-lead oxide product by mid-1978. Process descriptions so far available indicate that a proprietary smelting operation with full allowance for environmental considerations has been developed.[9] Studies by the Bureau of Mines of pyrometallurgical treatment of stainless steelmaking dusts for conservation of chromium, nickel, lead, and zinc progressed from laboratory to semicommercial scale.

Ferrophosphorus has been found acceptable as a partial replacement for zinc in corrosion resistant coatings on steel. Substitution for up to 50% by weight of zinc was feasible in automotive primers. In addition to being more economical, use of ferrophosphorus in place of zinc in primers improved welding and torch cutting operations and lowered associated evolution of fume.[10]

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[5]Mac Rae, D. R., R. G. Gold, C. D. Thompson, and W. R. Sandall. Ferrovanadium Production by Plasma Carbothermic Reduction of Vanadium Oxide. Proc. 34th Elec. Furnace Conf., ISS-AIME, St. Louis, Dec. 7-10, 1976, v. 34, pp. 96-100.

[6]Fey, M. G., and F. J. Harvey. Plasma Heating Devices in the Electric Energy Economy. Metals Eng. Quarterly, v. 16, No. 2, May 1976, pp. 27-30.

[7]Welsh, J. Y., and J. P. Faunce. The Production of Manganese Metal. Pres. at 105th Ann. Meeting of AIME, Las Vegas, Nev., Feb. 24, 1976, 7 pp.

[8]Bardenheuer, F., and S. Döhler. Ursachen und Beeinflussung der Wasserstoffgehalte in Ferro- und Silicomangan (Causes and Effects of Hydrogen in Ferromanganese and Silicomanganese). Stahl und Eisen, v. 96, No. 10/11, June 3, 1976, pp. 502-504.

[9]Skillings' Mining Review. Inco Plans Reclamation Plant for Mill Wastes. V. 65, No. 26, June 26, 1976, p. 10.

[10]Simko, F. A., Jr., and V. P. Simpson. New Class of Conductive Extenders in Zinc-Rich Coatings. J. Coatings Tech., v. 48, No. 614, March 1976, pp. 61-66.

Fluorspar

By C. K. Quan[1]

World fluorspar production dropped from the 1975 level, despite a slight increase in consumption resulting from a general recovery in aluminum and steel production. Mexican output, which attained a record 1.30 million tons in 1971, fell to a little under 1 million tons in 1976, the consequence of a continuing decline in U.S. reliance on Mexican fluorspar. Partially balanced against this is the Republic of South Africa's rise as an important producer, whose vast reserves, if exploited, may well make it a world leader in fluorspar production.

Environmental concerns over the possible effects of fluorocarbons on stratospheric ozone continued to depress the acid-grade fluorspar market, causing an oversupply situation which is expected to prevail until about 1980. Meanwhile, exploration for fluorspar and mine plant expansions were reported in several parts of the world, in anticipation of increased demand in the early eighties.

By far the largest users of fluorspar were steel furnaces, with 60% of estimated world consumption in 1976, followed by aluminum smelters with 19%, and fluorocarbons with 15%. Historically, growth in fluorspar demand roughly paralleled growths in aluminum and steel production. In recent times, however, growth projections are being tempered by new technology and stringent environmental regulations on fluorine emissions. The revolutionary Alcoa Smelting Process, which uses no fluorides in the production of aluminum, may well be a harbinger of difficult days ahead for the fluorspar market. Similarly, more efficient utilization and recycling of raw materials in

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Table 1.—Salient fluorspar statistics[1]

	1972	1973	1974	1975	1976
United States:					
Production:					
Mine production .... short tons..	710,668	561,149	447,253	376,601	611,133
Material beneficiated .... do....	771,411	663,361	409,005	401,477	574,678
Material recovered .... do....	245,047	232,891	207,816	132,060	182,582
Finished (shipments) .... do....	250,347	248,601	201,116	139,913	188,270
Value f.o.b. mine ..... thousands..	$17,315	$17,381	$14,297	$10,888	$17,927
Exports .... short tons..	2,764	2,428	5,847	r1,384	4,923
Value[2] .... thousands..	$184	$171	$316	r$234	$764
Imports for consumption ..... short tons..	1,181,533	1,212,347	1,336,389	1,050,448	895,254
Value[3] .... thousands..	$47,851	$52,620	$60,988	r$66,899	$64,881
Consumption (reported) ...... short tons..	1,352,149	1,351,705	1,524,532	1,244,938	1,273,458
Consumption (apparent)[4] .... do....	1,487,933	1,508,759	1,428,719	r1,300,067	1,120,970
Stocks Dec. 31:					
Domestic mines:					
Crude .... do....	111,565	57,901	44,196	57,833	88,905
Finished .... do....	15,295	8,675	13,668	11,386	14,870
Consumer .... do....	377,942	327,703	430,642	319,552	277,783
World: Production .... do....	4,992,406	r5,043,737	r5,355,079	r5,015,422	4,888,734

rRevised.
[1]Does not include fluosilicic acid and imports of hydrofluoric acid and cryolite.
[2]Questionable quantity or value.
[3]F.o.b. foreign port in 1972-74; c.i.f. port of entry in 1975-76.
[4]Apparent consumption includes finished shipments, plus imports, minus exports, and plus or minus consumer inventory changes.

new or existing smelters may result in further erosion of fluorspar demand, the extent of which is not yet readily predictable.

Legislation and Government Programs.—A House bill, H.R. 6254, was introduced in Congress on April 24, 1975, to provide for a 2-year suspension of tariff on imported fluorspar. The bill lapsed with the adjournment of Congress in 1976.

In mid-September, the National Academy of Sciences announced that chlorofluorocarbons (more commonly called fluorocarbons) posed a legitimate threat to man's environment.[2] Fluorocarbons, particularly those used as aerosol propellants, rise through the atmosphere and are subsequently photolyzed by ultraviolet radiation into chlorine atoms which then react catalytically with ozone, depleting it. The consequence of ozone diminution in the stratosphere is an increase in the amount of damaging ultraviolet radiation reaching the earth's surface, which may potentially raise the incidence of skin cancer, cause eye damage, and accelerate aging, as well as modify the earth's climate. In the wake of the National Academy of Sciences pronouncements, the Food and Drug Administration (FDA) proposed rules requiring warning labels on most aerosol products containing fluorocarbon propellants.[3] The labels would read: "Warning: Contains a chlorofluorocarbon that may harm the public health and environment by reducing ozone in the upper atmosphere." At yearend, the FDA, the Consumer Product Safety Commission, (CPSC) and the Environmental Protection Agency (EPA) announced plans to phase out nonessential uses of certain fluorocarbons. Rules pertaining to fluorocarbon manufacture and use are expected in early 1977. The potential technologic and economic impact of possible legislation on the fluorspar, fluorocarbon, and related industries have been examined by Shamel;[4] Brennan;[5] the Department of Commerce;[6] and Commodities Research Unit, Ltd.[7]

New emission standards for aluminum smelters being modified or under construction were finalized by the EPA in January 1976,[8] and require the removal of 95% of fluoride emissions from stack gases before release into the atmosphere. Emissions from prebake plants were limited to 1.9 pounds of fluoride per ton of aluminum produced, and 2.0 pounds per ton from Soderberg plants. For either process, opacity of the emissions was limited to 10%. Fluorine emissions from anode bake plants were limited to 0.1 pound per ton of anode produced, and opacity of the emissions to 20%.

Government stockpiles of strategic and critical materials contained 890,000 tons of acid-grade and 412,000 tons of metallurgical-grade fluorspar. On October 1, 1976, the Federal Preparedness Agency (FPA) of the General Services Administration (GSA) announced new stockpile goals, increasing the acid-grade fluorspar goal to 1,594,000 tons and metallurgical-grade fluorspar goal to 1,914,000 tons. These new goals would have significant impact on the fluorspar industry should Congress decide to fulfill them through short-term purchases.

As in years past, mining of domestic reserves was granted a 22% depletion allowance against Federal income tax, compared with 14% for foreign reserves.

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[2]Committee on Impacts of Stratospheric Change. National Academy of Sciences. Halocarbons: Environmental Effects of Chlorofluoromethane Release. 1976, 125 pp.
Panel on Atmospheric Chemistry. National Academy of Sciences. Halocarbons: Effects on Stratospheric Ozone. 1976, 352 pp.

[3]U.S. Food and Drug Administration. Fluorocarbons and Other Halocarbons in Foods, Drugs, Animal Drugs, Biological Products, Cosmetics, and Medical Devices. Federal Register, v. 41, No. 229, Nov. 26, 1976, pp. 52070-52079.

[4]Shamel, R. E., O'Neill, J. K., and Williams, R. Preliminary Economic Impact Assessment of Possible Regulatory Action To Control Atmospheric Emissions of Selected Halocarbons. Arthur D. Little, Inc., 1976, 302 pp.

[5]Brennan, R. P., Lau, R. W. J., and Patmore, J. W. Fluorocarbons and the Environment: A Preliminary Technology Assessment. Systems Control, Inc., 1976, 150 pp.

[6]Bureau of Domestic Commerce, U.S. Department of Commerce. Economic Significance of Fluorocarbons. 1975, 176 pp.

[7]Commodities Research Unit, Ltd. (United Kingdom). The Effect on the Acid-Grade Fluorspar Industry of Legislation Restricting the Use of Fluorocarbons. 1976, 100 pp.

[8]U.S. Environmental Protection Agency. Performance Standards for New Stationary Sources. Primary Aluminum Industry. Part 3. Federal Register, v. 41, No. 17, Jan. 26, 1976, pp. 3826-3830.

DOMESTIC PRODUCTION

Domestic shipments of all grades of fluorspar were 188,270 tons, 35% over 1975 shipments. Shipments from the Illinois-Kentucky district represented 85% of the total volume; the balance came from Arizona, Montana, Nevada, Texas, and Utah. Three major companies operating nine mines and three flotation circuits in Illinois and Kentucky accounted for 83% of the total output. Small, intermittent operations or shipments from inventory in Illinois and the Western States accounted for the remainder of the supply. A list of domestic producers with reported output in 1976 follows:

State	Company	Mines	Type of mills
Arizona	Tonto Mining and Milling Co	Bluebird[1]	Flotation.
	Western Fluorspar Co	Turkey	None.
Illinois	Allied Chemical Corp	Spivey, Gaskin, Deardorf and Minerva No. 1.	Heavy-medium and flotation.
	Ozark-Mahoning Co	Barnett, Knight, Oxford and H-M shaft.	Heavy-medium, flotation and briquetting.
	Hastie Mining Co	Spar Mountain	Heavy-medium.
	Tamora Mining Co	None[2]	Washing and screening.
Kentucky	Frontier Spar Corp	Babb-Barnes	Heavy-medium and flotation.
	Kenspar Co	Various residual deposits.	Do.[3]
Montana	Roberts Mining Co	Crystal Mountain[4]	Heavy-medium.
Nevada	J. Irving Crowell, Jr. & Sons	Daisy	None.
Texas	D & F Minerals Co	Paisano	Do.
Utah	U.S. Energy Corp	Fluoride Queen	Do.

[1]Processed crude ore from Bluebird and Turkey mines.
[2]Shipments of purchased ore.
[3]Plant undergoing expansion.
[4]Shipments from inventory only.

Estimated annual production capacity was some 350,000 tons, and domestic producers operated at about 54% of capacity in 1976. This compared with a 40% capacity utilization in 1975, a relatively poor year for an industry impacted by a 3-month labor dispute and a generally weak fluorspar market. In terms of demand, domestic producers provided 15% of total reported consumption, compared with 11% in 1975.

In Kentucky, Minerals Exploration Co. and Armco Fluorspar Corp., a wholly owned subsidiary of Armco Steel Corp., entered into a joint venture, giving rise to Kenspar Co. Initial production was to come from various residual deposits on previously owned Minerals Exploration properties near Mexico, Ky., but plans were underway for extensive underground exploration by diamond drilling and drifting from a vertical shaft nearby. Included in the plans was an expansion program incorporating a new flotation circuit in a mill leased from Ozark-Mahoning Co. When completed, the Kenspar project will provide output for captive usage by Armco Steel as well as for commercial sales.

At yearend, Pan Ocean Oil Co., a wholly owned subsidiary of Marathon Oil Co., announced the acquisition of Frontier Resources Inc. of Denver, renaming Cerro Spar Corp.'s operations near Salem, Ky., Frontier Spar Corp. Prior to the acquisition by Pan Ocean Oil, Cerro Spar was a 95% subsidiary of Frontier Resources, with the remaining stock held by a private individual. Mine and mill activities initiated by Cerro Spar were continued under the new ownership, and plans were made for the possible development of a new mine near Hampton, Ky., and the expansion of the existing mill in 1977.

Ozark-Mahoning Co., a subsidiary of Pennwalt Corp., and Allied Chemical Corp. continued as the largest domestic producers of fluorspar, with their operations in Pope and Harding Counties in southern Illinois. Output by Ozark-Mahoning consisted of acid and metallurgical grades of fluorspar, including briquets, while Allied Chemical's output comprised acid and ceramic grades. Both operators also recovered various amounts of lead, zinc, and barium concentrates as byproducts from their flotation circuits.

Tonto Mining and Milling Co., inactive in 1975, resumed shipments from its Tonto Basin, Ariz., operations in 1976. Feed for its flotation plant was derived from Tonto's Bluebird mine as well as from the Turkey mine of Western Fluorspar Co. Reportedly, shipments were made intermittently to Allied Chemical's hydrofluoric acid plant in Pittsburgh, Calif.

In Idaho, Domestic Power Co. continued exploration and evaluation of its fluorspar deposits located west of Challis. At yearend, a heavy-medium separation plant was reported to have been purchased for assembly on the property.

Extensive exploratory drilling was reported by Ozark-Mahoning and Allied Chemical in Illinois and by U.S. Borax and Chemical Corp. in Tennessee. Some 300,000 feet of drilling was logged in these two States. U.S. Borax, a subsidiary of Rio Tinto Zinc Co., is known to have delineated 50 million tons of ore containing 17% CaF_2 in a fluorspar-barite deposit in the Sweetwater district, some 40 miles southwest of Knoxville, Tenn. Some development of the ore body has been planned for 1977, but full production is not likely to materialize for several years.

Seven processors, operating at 58% of estimated annual capacity, supplied the steel industry with 292,000 tons of fluorspar briquets, valued at slightly in excess of $24 million, in 1976. The shipments represented gains of 34% in volume and 36% in value over those of 1975. With the exception of Ozark-Mahoning's plant in Illinois, plants elsewhere utilized imported fluorspar of various grades, averaging 78% CaF_2, to fabricate a finished product averaging 66% CaF_2. A list of domestic briquettors follows:

Processor	Location
Cametco, Inc	Duquesne, Pa.
Delhi Foundry Sand Co	Brownsville, Tex.
Mercier Corp	Dearborn, Mich.
National Briquet Corp	East Chicago, Ind.
Oglebay Norton and Co	Brownsville, Tex.
Ozark-Mahoning Co	Rosiclare, Ill.
Do	Brownsville, Tex.

Of increasing importance as a secondary source of domestic fluorine for the chemical and aluminum industries is byproduct fluosilicic acid, H_2SiF_6, recovered from the wet-process manufacture of phosphoric acid from fluorapatite. Eleven phosphoric acid plants processing some 9 million tons of phosphate rock recovered 70,000 tons of fluosilicic acid in 1976, a gain of 17% over 1975 byproduct recovery. Of the 70,000 tons of fluosilicic acid recovered, 47,000 tons was subsequently shipped to the consuming industries. Thus, the phosphoric acid industry supplied an equivalent of 38,000 tons of fluorine, or about 7% of total fluorine consumption. A list of domestic phosphoric acid plants reporting fluorine recovery in 1976 follows:

Processor	Location
Agrico Chemical Co	Pierce, Fla.
Borden Chemical Co	Norfolk, Va.
Central Phosphates, Inc	Plant City, Fla.
Farmland Industries	Bartow, Fla.
Gardinier (SOPAG), Inc	Tampa, Fla.
Mississippi Chemical Corp	Pascagoula, Miss.
Stauffer Chemical Co	Salt Lake City, Utah.
U.S.S. Agri-Chemicals	Bartow, Fla.
Do	Wilmington, N.C.
Do	Nashville, Tenn.
W. R. Grace & Co	Bartow, Fla.

At yearend, producers' inventories consisted of 9,063 tons of acid-grade fluorspar, up 66% from the 1975 figures, and 5,807 tons of metallurgical-grade material, down 2%.

Domestic reserves were estimated at 16 million tons of ore containing 35% CaF_2. Illinois and Kentucky accounted for 56% of total reserves; Colorado and Idaho, 36%; and Montana, Nevada, New Mexico, Texas, and Utah, the remainder. Domestic resources were described in two U.S. Geological Survey publications.[9]

[9]Pinckney, D. M. Mineral Resources of the Illinois-Kentucky Mining District. U.S. Geol. Survey Prof. Paper 970, 1976, pp. 1-15.

Table 2.—Shipments of finished fluorspar, by State

State	1975			1976		
		Value			Value	
	Quantity (short tons)	Total (thousands)	Average per ton	Quantity (short tons)	Total (thousands)	Average per ton
Illinois	99,898	$8,957	$89.66	142,666	$14,563	$102.08
Utah	9,542	389	40.77	W	W	W
Other States[1]	30,473	1,542	50.61	45,604	3,364	73.77
Total	139,913	10,888	77.82	188,270	17,927	95.22

W Withheld to avoid disclosing individual company confidential data.
[1]Montana, Kentucky, Nevada, and Texas (also Utah in 1976).

Table 3.—Shipments and mine stocks of finished fluorspar in the United States, by grade

Grade	1975				1976			
	Short tons	Value[1] (thousands)	Value per ton	Stocks[2]	Short tons	Value[1] (thousands)	Value per ton	Stocks[2]
Acid	56,944	$4,823	[r]$84.69	5,461	[3]116,300	$12,470	$107.23	9,063
Metallurgical	82,969	6,065	73.10	5,925	71,970	5,457	75.82	5,807
Total	139,913	10,888	77.82	11,386	188,270	17,927	95.22	14,870

[r]Revised.
[1]Total value as reported by mine production.
[2]Mine stocks as of Dec. 31.
[3]Includes #1 ceramic grade.

CONSUMPTION AND USES

Fluorspar is an important industrial mineral, valued for its fluxing properties and as a principal source of fluorine. Although not a major commodity in terms of total quantity produced annually, it is a critical raw material for the steel, aluminum, and chemical industries.

Different grades of fluorspar are required for various uses. Acid-grade, containing more than 97% CaF_2, is feedstock for the manufacture of hydrofluoric acid, a key ingredient for the aluminum and fluorochemical industries. Ceramic-grade, containing between 85% and 97% CaF_2, is used in the ceramics industry for the production of glass and enamel. Increasingly, acid-grade material is being used by the ceramics industry in order to capitalize on its low import duty. On the other hand, some hydrofluoric acid manufacturers are finding it economically advantageous to utilize ceramic-grade material, provided some contaminants are properly controlled. Metallurgical-grade fluorspar, containing between 60% and 85% CaF_2, is used almost exclusively in the iron and steel industries. In the United States, metallurgical-grade fluorspar is customarily quoted in terms of effective units, obtained by subtracting two and a half times the silica content of the ore from the CaF_2 content. Traditionally, a minimum of 70% effective CaF_2 has been used in the steel furnaces, but in recent times lower grade material, including briquets, is gaining widespread usage.

Most of the ceramic and metallurgical applications for fluorspar are derived from its ability to form lower melting eutectics with refractory materials. In steelmaking it assists in the effective desulfurization and dephosphorization of the melt, promotes slag fluidity, and enhances the solution of lime. Of particular importance to basic oxygen furnace use is its ability to sustain a stable foam emulsion during the refining process. Fluorspar usage in steelmaking varies considerably among individual companies and mills. In 1976, major U.S. steel mills reportedly consumed 606,578 tons of fluorspar; open hearth furnaces accounted for 92,792 tons, basic oxygen furnaces, for 423,493 tons and electric furnaces for 90,293 tons (table 4). According to the American Iron and Steel Institute, domestic production of raw steel for the year amounted to 127,943,000 tons, of which 23,470,000 tons was from open hearth furnaces, 79,918,000 tons from basic oxygen furnaces, and 24,555,000 tons from electric furnaces. Overall, the steel industry consumed about 9.5 pounds of fluorspar per ton of crude steel produced. On the basis of furnace type, the average fluorspar consumption per ton of raw steel is computed as follows:

Type of furnace	Fluorspar consumption pounds per ton
Open hearth	7.9
Basic oxygen	10.6
Electric	7.3

Briquets averaging 76% CaF_2 accounted for a little over 30% of the total fluorspar consumption by the steel industry. With rapidly diminishing supplies of good-quality metallurgical-grade fluorspar, it is anticipated that the trend towards increased usage of briquets will continue. The uniformity in grade of the briquet and its convenience in handling make it an attractive alternative to natural fluorspar.

Hydrofluoric acid is made by the reaction of acid-grade fluorspar with sulfuric acid. About 2.2 tons of fluorspar are required per ton of acid produced. Acid-grade fluorspar consumption by 12 domestic hydrofluoric acid plants amounted to 631,284 tons, down 6% from that of 1975. A contributing factor to the decline in consumption was the cessation of DuPont's production at Deepwater, N.J., at yearend 1975, and the partial shutdown of Allied Chemical's plant at Claymont, Del., during 1976. It is anticipated that Du Pont's future requirements will be met by Quimica Fluor, S.A., whose hydrofluoric acid plant came onstream in 1976 at Matamoros, Tamaulipas, Mexico. Du Pont is part owner of Quimica Fluor. A list of domestic hydrofluoric acid plants follows:

Producer	Plant location	Estimated capacity tons per year
Aluminum Company of America (Alcoa).	Point Comfort, Tex	55,000
Allied Chemical Corp	Baton Rouge, La	
	Geismar, La	
	Nitro, W.Va	108,000
	North Claymont, Del	
	Port Chicago, Calif	
Du Pont Company	Strang, Tex	75,000
Essex Chemical Corp	Paulsboro, N.J	11,000
Harshaw Chemical Co	Cleveland, Ohio	18,000
Kaiser Aluminum	Gramercy, La	50,000
Pennwalt Corp	Calvert City, Ky	25,000
Stauffer Chemical Co	Houston, Tex	18,000
Total		360,000

Source: Chemical Marketing Reporter.

Total hydrofluoric acid produced for captive usage as well as for general consumption in 1976 amounted to 288,200 tons, according to the U.S. Department of Commerce. An additional 85,500 tons, worth about $41 million, was available from imports, principally from Mexico and Canada. Total hydrofluoric acid supply, therefore, amounted to 373,700 tons. Major end uses of hydrofluoric acid comprised fluorocarbon production, aluminum refining, petroleum alkylation, uranium enrichment, stainless steel pickling, the production of fluorine compounds other than fluorocarbons, and miscellaneous uses.

The term "fluorocarbons" is applied to all organic fluorine chemicals, most of which are chlorofluorocarbons and the remainder fluorocarbons and other fluorine chemicals. Fluorocarbons possess properties that render them eminently useful as refrigerants and aerosol propellants. They are nontoxic, odorless, and nonflammable. Being chemically stable, they do not react with the products with which they are packaged. They also have the advantage of liquefying easily under slight pressure.

Five fluorocarbons account for nearly 95% of total domestic fluorocarbon production, as follows:

Fluorocarbon No.	Chemical name	Molecular formula
F11	Trichlorofluoromethane	CCl_3F
F12	Dichlorodifluoromethane	CCl_2F_2
F22	Chlorodifluoromethane	$CHClF_2$
F113	Trichlorotrifluoroethane	$CCl_2F\text{-}CClF_2$
F114	Dichlorotetrafluoroethane	$CClF_2\text{-}CClF_2$

Most fluorocarbons are manufactured by by the catalytic reaction of hydrofluoric acid with carbon tetrachloride, chloroform, or perchloroethylene. The average consumption of hydrofluoric acid is 0.25 to 0.50 pound per pound of fluorocarbon produced, depending on the product, but for the foregoing major products an average of 0.35 pound per pound appears reasonable. Six producers with an estimated annual capacity of 595,000 tons account for the entire domestic fluorocarbon output:

Producer	Plant location	Estimated capacity tons per year
Allied Chemical Corp	Baton Rouge, La	
	Denville, Ill	150,000
	Elizabeth, N.J	
	El Segundo, Calif	
Du Pont Company	Antioch, Calif	
	Pennsville, N.J	
	East Chicago, Ind	250,000
	Louisville, Ky	
	Montage, Mich	
	Corpus Christi, Tex	
Kaiser Aluminum	Gramercy, La	25,000
Pennwalt Corp	Calvert City, Ky	60,000
	Thorofare, N.J	
Racon Corp	Wichita, Kans	10,000
Union Carbide Corp	Institute, W.Va	100,000
Total		595,000

Sources: Chemical Marketing Reporter, and Arthur D. Little, Inc.

Prior to 1974, approximately half of all fluorocarbon production was used as aerosol propellants in antiperspirants, deodorants, hair sprays, paints, and household disinfectants. This market was growing at about 8% annually then. The second major use for fluorocarbons was as a refrigerant, accounting for 28% of all fluorocarbons. Foamblowing accounted for about 7% of total consumption; solvents, 5%; plastics and resins, 4%; and exports and other uses, 7%. Since late 1974, however, the growth in aerosol propellant usage has been significantly slowed by controversy over environmental degradation due to the presence of fluorocarbons in the stratosphere. It has been estimated that aerosol propellants now account for only 30% of U.S. fluorocarbon consumption and will continue to decline in years to come as laws are promulgated restricting nonessential uses of fluorocarbons.

Production of fluorocarbons F11 and F12, amounted to 312,100 tons in 1976, according to the U.S. International Trade Commission. While data on other fluorocarbons are unavailable, total production of all fluorocarbons is estimated at 450,000 tons, down 7% from that of 1975. This production accounted for 157,500 tons of hydrofluoric acid, or 42% of total supply for the year.

Hydrofluoric acid is not consumed directly in aluminum smelting but is used to produce aluminum fluoride (AlF_3) and synthetic cryolite (Na_3AlF_6) by reaction with alumina and caustic soda, respectively. Subsequently, cryolite and aluminum fluoride are used with alumina in the molten bath from which aluminum is produced by electrolysis. Aluminum fluoride is added to the electrolyte to lower its melting point, but only a limited amount can be added because it also reduces the electrical conductivity. Small amounts of fluorspar are therefore added to further reduce the melting point without also reducing the electrical conductivity. Previously, some natural cryolite, primarily from Greenland and now very rare, was used in the potlines, but today nearly all the fluorides are produced from hydrofluoric acid. The fluorides do not enter the final product but are absorbed in potlinings or discharged into the air as particulates or gases. Fluoride consumption varies with individual smelters but averages 60 pounds of aluminum fluoride and 50 pounds of cryolite per ton of aluminum ingot produced. This is equivalent to about 70 pounds of hydrofluoric acid per ton of aluminum. In recent times, however, the actual amount of hydrofluoric acid required is probably 20% less, or 56 pounds, owing to recycling of fluoride values from potlines and flue gases, as well as the manufacture of aluminum fluoride and cryolite from fluosilicic acid.

Six major companies - Aluminum Company of America, Allied Chemical Corp., Kaiser Aluminum, Olin Corp., Stauffer Chemical Co., and Reynolds Metals Co. - account for most of the domestic production of aluminum fluoride and synthetic cryolite. All are partially or completely integrated with facilities producing hydrofluoric acid and aluminum. For some years Kaiser has also produced cryolite from sodium silicofluoride, while Alcoa produced both cryolite and aluminum fluoride from fluosilicic acid. This is in addition to their cryolite and aluminum fluoride production from hydrofluoric acid.

According to the Aluminum Association, domestic production of primary aluminum in 1976 amounted to 4,251,500 tons, up 10% from that of 1975. This accounted for about 119,000 tons, or 32% of total hydrofluoric acid supply for the year.

The enrichment of uranium in the fissile isotope, U_{235}, is either by the conventional gaseous diffusion process or by the more recent gas centrifuge process. Both processes involve the use of uranium hexafluoride, UF_6, as the form in which the isotope separation takes place. Uranium hexafluoride is convenient for this purpose because it is gaseous at moderate temperatures. Yellowcake, containing 80% to 85% U_3O_8, is first refined to purified UO_3. This is followed by reaction with anhydrous hydrofluoric acid to produce greensalt, UF_4. The final stage involves the conversion of greensalt to uranium hexafluoride by means of elemental fluorine. Total hydrofluoric acid requirement by the entire process is estimated at 1.1 tons per ton of uranium hexafluoride produced.

It is estimated that about 11,000 tons of U_3O_8 were processed in 1976, requiring 12,100 tons, or 3% of total hydrofluoric acid supply. Uranium enrichment is probably the fastest growing end use market for hydrofluoric acid. Although a relatively minor demand, it is important and will continue to grow in parallel with the growth of nuclear power facilities.

The hydrofluoric acid alkylation process is one of several processes available for the alkylation of propene- and butylene-type olefins. Approximately 0.33 pound of hydrofluoric acid is used in the production of 1 barrel of alkylate. Estimated 1976 consumption by this end use was about 12,000 tons, or 3% of total hydrofluoric acid supply.

Apart from uranium enrichment, the largest single use of anhydrous hydrofluoric acid is in stainless steel pickling, which utilizes the acid for descaling after rolling operations. However, not all grades of stainless steel are pickled with hydrofluoric acid, some requiring only nitric acid or a molten caustic bath. Consumption of hydrofluoric acid varies but apparently averages 25 pounds per ton of stainless steel pickled. Domestic production of stainless steel amounted to 1,684,000 tons in 1976, up 52% from that of 1975. Assuming that 42%, or 707,000 tons, was pickled by hydrofluoric acid, the total hydrofluoric acid consumption amounted to about 8,800 tons, or 2% of total supply.

Inorganic fluorides other than aluminum fluoride and cryolite are also produced from hydrofluoric acid, but are difficult to define in quantities and end uses because of the large number of individual salts and their relatively small volume. Sodium fluoride is the largest volume inorganic fluoride in this group. In the past it was used primarily in water fluoridation, steelmaking, wood preservatives, insecticides, fungicides, and fluxing agents. Use for water fluoridation has declined in favor of lower cost silicofluorides. Sodium bifluoride is used in the electrotinning of steel and in laundry applications. Boron trifluoride is used as a catalyst in the production of alkylated phenols, coumarone-indene resins, and petroleum resins, and as an accelerator in epoxy hardeners. Fluoboric acid has applications in the electropolishing of aluminum, while stannous fluoride is well known as a decay preventive in toothpaste.

Seven major companies - Allied Chemical Corp., Olin Corp., Essex Chemical Corp., Harshaw Chemical Co., Kawecki-Berylo Industries, Inc., Mallinckrodt, Inc., and Chemtech Industries, Inc. - account for most of the inorganic fluoride production and in 1976 probably consumed about 9,000 tons, or 2% of total hydrofluoric acid supply.

Miscellaneous uses of hydrofluoric acid include the production of specialty metals, such as beryllium, columbium, tantalum, and yttrium; etching and frosting of glass; and use in the electronics industry. These numerous end uses probably consumed half the balance of the 1976 supply of hydrofluoric acid, about 54,000 tons; the remainder went into inventory.

In addition to the fluorspar consumed in the steel and hydrofluoric acid industries, some 35,636 tons of fluorspar was reportedly used in the manufacture of glass, enamel, welding rod coatings, primary magnesium, iron and steel castings, and special ferroalloys. These miscellaneous end uses represented about 3% of the entire domestic fluorspar consumption in 1976.

In summary, reported domestic fluorspar consumption amounted to 1,273,458 tons in 1976, up only 2% from that of 1975. About half of the total consumption was acid-grade; the remainder was metallurgical-grade. Raw steel production accounted for 48% of total fluorspar consumed; fluorocarbons and other fluorine compounds, 22%; and primary aluminum, 16%. The remaining, 14%, was used in stainless steel pickling, uranium enrichment, petroleum alkylation, primary magnesium and ferroalloy production, ceramics, welding rod coatings, etching and frosting of glass, and various other end use categories.

Supplementing the domestic supply of fluorine was byproduct fluosilicic acid recovered from wet-process phosphoric acid plants. In 1976, some 47,000 tons of fluosilicic acid was shipped, 77% to producers of synthetic cryolite and aluminum fluoride, 21% to manufacturers of other fluorine compounds, and the balance to water fluoridation plants.

At yearend, consumers' inventories comprised 66,641 tons of acid-grade fluorspar, up 33% from 1975 inventories, and 211,142 tons metallurgical-grade material, down 22%.

Table 4.—Reported domestic consumption of fluorspar in 1976, by end use and grade

(Short tons)

End use or product	Containing more than 97% calcium fluoride	Containing not more than 97% calcium fluoride	Total
Hydrofluoric acid	631,284	--	631,284
Glass and fiber glass	4,928	6,281	11,209
Enamel and pottery	453	380	833
Welding rod coatings	W	W	W
Primary aluminum and magnesium	836	W	836
Other nonferrous metal	W	W	W
Iron and steel castings	--	14,751	14,751
Open hearth furnaces	--	92,792	92,792
Basic oxygen furnaces	--	423,493	423,493
Electric furnaces	1,312	88,981	90,293
Other uses or products	4,147	3,820	7,967
Total	642,960	630,498	1,273,458
Stocks Dec. 31, 1976	66,641	211,142	277,783
Stocks Dec. 31, 1975	50,200	269,352	319,552

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."

PRICES

Prices rose slightly at the beginning of the year but stabilized thereafter. Yearend quotations by the Engineering and Mining Journal are presented in table 5. Domestic metspar (metallurgical-grade fluorspar) briquets sold for $91 per ton, 3% over the 1975 price. At the Mexican border, metspar prices gained 3% to 4% compared with 7% to 8% for acidspar (acid-grade fluorspar). The devaluation of the Mexican peso appeared to have no significant impact on prices, presumably because most contracts were drawn in terms of U.S. dollars. European and South African acid-grade concentrates suffered some price fluctuations, but averaged about 3% lower than the average price in 1975.

Table 5.—Prices of domestic and imported fluorspar

(Dollars per short ton)

	1975	1976
Domestic, f.o.b. Illinois-Kentucky:		
Metallurgical: 70% effective CaF_2 briquets	83-88	83-91
Ceramic, variable calcite and silica:		
88% to 90% CaF_2	90-100	90-100
95% to 96% CaF_2	95-106	95-106
97% CaF_2	100-115	100-115
Acid, dry basis, 97% CaF_2:		
Carloads	95-115	95-115
88% effective briquets	105	111
European and South African:[1] Acid, term contracts	95-107	102.50-105.00
Mexican:[2]		
Metallurgical:		
70% effective CaF_2, f.o.b. vessel, Tampico	63.00-63.50	65.52
70% effective CaF_2, f.o.b. cars, Mexican border	60.50-61.00	62.92
Acid, bulk: 97%+, Mexican border	73.50-74.00	79.38

[1]C.i.f. East Coast, Great Lakes and gulf ports.
[2]U.S. import duty, insurance, and freight not included.

Source: Engineering and Mining Journal, December 1975 and 1976.

FOREIGN TRADE

Fluorspar exports, principally to Canada, have always been an insignificant part of the U.S. trade balance. In 1976 some 4,900 tons were reportedly shipped abroad (table 6), Canada absorbing 86% of the total volume; prices were not certain.

As domestic production has been inadequate for domestic demand since the early fifties, the United States continues to rely heavily on foreign sources of fluorspar. From a record 1.34 million tons in 1974, U.S. imports fell to 1.05 million tons in 1975 and further to 0.89 million tons in 1976 (table 7), reflecting a steady decline in import reliance. About two-thirds of total imports in 1976 consisted of acid-grade fluorspar; the balance was metallurgical-grade material. The aggregate value was $64.88 million, not including duty, at ports of entry. Traditionally, Mexico has been the largest source of imported fluorspar, accounting for well over 70% of all imports since the early sixties, but in 1976 its share of the U.S. market fell to about 61%, giving way to incursions of South African material. Presumably, most South African fluorspar, which represented 14% of total imports, entered the United States for captive usage by a parent steel company. Other countries contributing significantly to U.S. imports included Spain (12%) and Italy (6%).

Since 1972, imports of hydrofluoric acid have been steadily rising, from about 14,000 tons to well over 85,000 tons in 1976 (table 8). Until recently, Canada was the major supplier, accounting for over 90% of U.S. imports. The position changed somewhat in 1975 when Mexico, in line with her new export policies, increased shipments almost sevenfold over those of 1974, thereby claiming a third of the U.S. market. Mexican shipments more than tripled in 1976, largely the result of the first full year of operations of the Quimica Fluor plant at Matamoros, establishing Mexico as the leading supplier of hydrofluoric acid to the United States. Despite its low volume, the total value of hydrofluoric acid imports amounted to $41 million, almost comparable to that of the relatively high-volume fluorspar. Unlike fluorspar, hydrofluoric acid is not subject to import duty.

Supplementing domestic supplies of cryolite, some 11,300 tons of the commodity, valued at $5.14 million, were imported in 1976 (table 9). The principal foreign suppliers of cryolite, most of which was synthetic, were Japan, the People's Republic of China, and Denmark, together accounting for 86% of total imports.

The current tariffs on imported fluorspar, established in 1951, remained effective in 1976, as follows:

Tariff class	TSUS No.	Tariff rate: Per long ton	Tariff rate: Per short ton	Statutory rate per long ton
Fluorspar containing more than 97% CaF_2	522.21	$2.10	$1.87	$5.60
Fluorspar containing less than 97% CaF_2	522.24	8.40	7.50	8.40

Table 6.—U.S. exports of fluorspar

Year and country	Quantity (short tons)	Value
1973	2,428	$171,255
1974	5,847	315,852
1975[r]	1,384	233,602
1976:		
Argentina	32	14,045
Brazil	30	43,861
Canada	4,251	581,138
Dominican Republic	260	36,058
Mexico	273	22,131
Saudi Arabia	4	910
South Africa, Republic of	41	7,120
United Kingdom	22	54,240
Venezuela	10	4,254
Total	4,923	763,757

[r]Revised.

Table 7.—U.S. imports for consumption of fluorspar, by country and customs district

Country and customs district	1975			1976		
	Quantity (short tons)	Value (thousands)		Quantity (short tons)	Value (thousands)	
		Customs	C.i.f.		Customs	C.i.f.
CONTAINING MORE THAN 97% CALCIUM FLUORIDE						
Brazil: Philadelphia	10,676	$739	$906	--	--	--
Canada: Laredo	--	--	--	77	$6	$6
France:						
Cleveland	--	--	--	7,720	556	734
Philadelphia	6,842	532	681	--	--	--
Total	6,842	532	681	7,720	556	734
Italy:						
Galveston	27,016	1,977	2,298	49,510	3,765	4,194
New Orleans	7,798	582	675	7,854	635	714
Total	34,814	2,559	2,973	57,364	4,400	4,908
Kenya:						
Detroit	11,618	604	782	15,056	656	918
Houston	--	--	--	6,366	398	495
Total	11,618	604	782	21,422	1,054	1,413
Mexico:						
El Paso	92,154	5,021	5,725	88,910	4,947	7,429
Laredo	354,250	23,669	24,511	212,310	15,358	15,703
New Orleans	--	--	--	4,334	339	372
Philadelphia	13,238	712	758	--	--	--
Total	459,642	29,402	30,994	305,554	20,644	23,504
Morocco: Philadelphia	5,824	474	502	--	--	--
South Africa, Republic of:						
Detroit	10,364	682	873	8,489	567	723
Laredo	--	--	--	4,874	283	366
New Orleans	8,337	527	647	74,918	4,544	5,454
Total	18,701	1,209	1,520	88,281	5,394	6,543

Table 7.—U.S. imports for consumption of fluorspar, by country and customs district —Continued

Country and customs district	1975 Quantity (short tons)	1975 Value (thousands) Customs	1975 Value (thousands) C.i.f.	1976 Quantity (short tons)	1976 Value (thousands) Customs	1976 Value (thousands) C.i.f.
CONTAINING MORE THAN 97% CALCIUM FLUORIDE—Continued						
Spain:						
Cleveland	44,262	$3,582	$4,779	21,108	$1,511	$2,005
Galveston	6,394	403	507	--	--	--
Houston	--	--	--	28,505	2,157	3,014
New Orleans	--	--	--	9,941	836	1,031
Philadelphia	75,821	4,913	5,212	16,354	1,407	1,611
Total	126,477	8,898	10,498	75,908	5,911	7,661
Taiwan: Houston	--	--	--	6,943	515	520
Thailand: New Orleans	17,543	856	1,186	27,945	1,330	1,771
Tunisia: New Orleans	7,282	457	602	--	--	--
Grand total	699,419	45,730	50,644	591,214	39,810	47,060
CONTAINING NOT MORE THAN 97% CALCIUM FLUORIDE						
Brazil: New York	--	--	--	2	1	1
Canada:						
Buffalo	11,830	650	710	--	--	--
Detroit	5,009	390	471	43	4	2
Total	16,839	1,040	1,181	43	4	2
Mexico:						
Baltimore	15,641	915	948	--	--	--
Buffalo	9,486	532	624	20,366	1,248	1,425
Cleveland	10,054	499	663	--	--	--
Detroit	9,930	492	638	--	--	--
El Paso	20,568	654	654	14,270	505	504
Laredo	253,616	10,347	10,647	196,583	9,945	10,029
New Orleans	8,611	542	582	--	--	--
Philadelphia	6,172	305	313	7,986	729	868
St. Albans	56	2	3	--	--	--
San Francisco	56	1	1	--	--	--
Total	334,190	14,289	15,073	239,205	12,427	12,826
South Africa, Republic of: New Orleans	--	--	--	34,020	1,804	2,334
Spain:						
Baltimore	--	--	--	23,330	1,894	2,007
Philadelphia	--	--	--	7,440	640	651
Total	--	--	--	30,770	2,534	2,658
United Kingdom	(1)	(1)	1	--	--	--
Grand total	351,029	15,329	16,255	304,040	16,770	17,821

[1] Less than 1/2 unit.

Table 8.—U. S. imports for consumption of 70% hydrofluoric acid

Country	1975 Quantity (short tons)	1975 Value (thousands) Customs	1975 Value (thousands) C.i.f.	1976 Quantity (short tons)	1976 Value (thousands) Customs	1976 Value (thousands) C.i.f.
Canada	31,895	$13,950	$14,362	36,675	$17,041	$17,170
Germany, West	(1)	1	1	--	--	--
Israel	(1)	1	1	--	--	--
Japan	227	94	138	105	49	63
Mexico	13,786	6,142	6,145	48,672	23,712	23,724
United Kingdom	331	149	165	78	33	43
Total	46,239	20,337	20,812	85,530	40,835	41,000

[1] Less than 1/2 unit.

Table 9.—U.S. imports for consumption of cryolite[1]

Year and country	Quantity (short tons)	Value (thousands) Customs	Value (thousands) C.i.f.
1973	19,789	$5,052	$5,911
1974	r21,216	r6,969	8,209
1975	22,120	9,058	10,555
1976:			
Austria	6	5	6
Canada	203	90	95
China, People's Republic of	3,012	1,231	1,442
Denmark	1,962	802	928
Germany, West	707	326	370
Hungary	332	143	171
Japan	4,940	1,670	2,050
Netherlands	55	25	29
Sweden	44	12	16
Switzerland	1	(2)	(2)
Taiwan	20	8	9
United Kingdom	43	17	20
Total	11,325	4,329	5,136

rRevised.
1Only the material from Denmark is natural cryolite. All other is manufactured synthetic cryolite.
2Less than 1/2 unit.

WORLD REVIEW

World production of fluorspar in 1976, table 10, estimated at 4.89 million tons, was down 3% from the 1975 level of 5.01 million tons. Mexico remained the leading producer, with 20% of the total output, followed by the U.S.S.R., 11%; France, 8%; the People's Republic of China, 8%; Mongolia, 7%; Spain, 7%; and the Republic of South Africa, 7%. More than 60% of the total output, almost equally divided between acid-grade and metallurgical-grade fluorspar, probably entered the export markets in 1976 (as in 1975, table 11), with the remainder consumed by captive markets in producer countries or else stockpiled for future demand.

Producer inventories, built up in 1975 on account of worldwide industrial recession, remained virtually unchanged at yearend 1976. Presumably, well over half a million tons of fluorspar existed in producer stockpiles, leading to an oversupply situation expected to prevail for the next few years. Depressed market conditions notwithstanding, plant expansions and exploration continued in several countries in anticipation of improved demand by the early 1980's.

World consumption of fluorspar in 1976, estimated at 4.57 million tons, rose 4% over the estimated consumption level of 4.41 million tons in 1975, reflecting a recovery in the steel and aluminum industries. Environmental concerns over the possible damage of the ozone layer in the earth's stratosphere by fluorocarbons continued to depress the fluorocarbon industry.

At yearend 1976, world fluorspar production capacity was estimated at 6.5 million tons, about 54% of which was acidspar and the remainder metspar or other grades of fluorspar. This installed annual capacity was considered adequate to meet projected demands until the early 1980's after which time production facilities will have to expand with consumption. World reserves of fluorspar have been variously estimated at between 222 million tons and 360 million tons of ore containing a minimum of 25% to 35% CaF_2. At current rates of extraction, it is anticipated that these reserves will be depleted within the next two decades. However, new technology and additional exploration, coupled with a more attractive price structure, are expected to enhance the reserve base in years to come.

WORLD PRODUCTION

Argentina.—Output from Argentina, which attained a high of 80,000 tons in 1971, dropped in succeeding years to its present level of about 41,000 tons, and recovery is not anticipated in the near future. Practically all output came from the operations of one company, the Sierra Grande Co., in the Province of Chubut and Rio Negro.

Brazil.—Brazilian output has consistently increased or else held firm since 1973, the first year of reported production, and provides adequately for the country's developing aluminum, steel, and chemical industries. In line with the national policy of self-sufficiency, exports are under strict government control, although in recent years shipments have been made to the United States and Japan. Four companies, the largest of which was Mineracao Santa Catarina, accounted for all of Brazilian output, which amounted to about 71,000 tons in 1976. Most production came from the Crisciuma-Tubaro district in the State of Santa Catarina.

Canada.—Canadian fluorspar production continued to be inadequate to meet domestic needs. From a record 180,000 tons in 1972, production fell considerably to 70,000 tons in 1975, owing to a labor strike that began at midyear and continued into February 1976. The Aluminum Co. of Canada (Alcan), through a subsidiary, Newfoundland Fluorspar, Ltd., is the sole producer of fluorspar in the country. Production from Alcan's mines near the village of St. Lawrence, Newfoundland, did not exceed 80,000 tons in 1976, most of which was for captive usage at Alcan's aluminum fluoride and synthetic cryolite plant at Arvida, Quebec. In the face of accelerating production costs and recurrent labor problems, previously announced plans for mine and mill expansion are not expected to materialize in the immediate future. Increasingly, Canada's fluorspar requirements will continue to be met by low-cost supplies from Spain and Mexico.

China, People's Republic of.—Ranking among the world's leading producers and exporters of fluorspar, China's output in 1976 probably reached 385,000 tons. In contrast to its substantial production, domestic consumption by the still-developing aluminum, steel, and chemical industries has for years been rather modest. In consequence, a large surplus has always been available for export, primarily to Japan and the Soviet Union. China's output consists essentially of metallurgical-grade fluorspar, in which form it is exported, but some acid-grade material is produced at the Taoling mine in Hunan Province, which has an annual capacity of some 80,000 tons. In July 1976 a small shipment, some 6,900 tons, of acid-grade fluorspar was reported to have entered the United States on a trial basis; it is believed, however, that the shipment contained very high-grade lump material, and not flotation concentrates.

France.—French production was derived mainly from deposits in the Massif Central, the Eastern Pyrénées, and the Var District of Provence. Two private corporations, Péchiney-Ugine-Kuhlmann (PUK) and Sté. de Concentration des Mineraux Fluorés (Comifluor), provided about 70% of French output, which totaled 391,000 tons in 1976. For some years now French production has been more than adequate for domestic needs, with the result that about one-third is usually exported, primarily to West Germany.

Germany, West.—Mainly because of dwindling reserves, resulting in several mine closures, West German production has been steadily declining in recent years, from about 102,200 tons in 1972 to about 74,200 tons in 1976. Currently, output is based largely on the operations of Fluss und Schwerspatwerke Pforzheim, GmbH and VAW Flusspat Chemie, A.G. in the Black Forest and Bavaria.

Italy.—Italian production, almost entirely by two private corporations, Mineraria Silius, S.p.A., and Montecatini-Edison, S.p.A., is centered largely in the Brescia, Trento, Bolzano, and Bergamo areas of Northern Italy, and near Cagliari in Sardinia. Output from these areas is mainly acid-grade material, although some briquets have also been produced from flotation fines in recent years. Also in recent years, production has been steadily declining, from about 319,000 tons in 1970 to some 232,400 tons in 1976. About one-third of total production is generally exported to the United States, West Germany, and other European countries.

Kenya.—Of 24 mineral commodities produced in Kenya, fluorspar remains the chief contributor to export earnings. Exports of fluorspar earned $4.5 million in 1976. The

Fluorspar Co. of Kenya, partly owned by International Minerals and Chemical Corp., continued as the sole producer, with operations in the Kerio Valley of the Rift Valley Province. Largely as the result of the first full year of operations of the Fluorspar Co.'s new 165,000-ton-per-year flotation plant, Kenya became firmly established as the second largest producer on the African continent, with a total output of some 82,700 tons in 1976, compared with 60,200 tons in 1975. Development work continued on the extensive reserves of fluorspar, all of which occur as replacement bodies in limestone of the Mozambique crystalline basement.

Mexico.—Although Mexican production in 1976 was 18% less than in 1975, Mexico continued as the world's leading producer. Its output of 988,300 tons represented 20% of the world total. This sharp decline in production has been ascribed to a generally soft market as well as to declining U.S. import reliance on Mexican fluorspar. The erosion of Mexico's share of total U.S. imports, from 80% in 1974 to 61% in 1976, reflected a current trend for its traditional trading partners to seek alternative sources of cheap or captive material. To some extent, loss of sales to the United States has been offset by new markets in Europe and by increased domestic consumption. The domestic market for acid-grade material expanded considerably as result of the first full year of operation of the Quimica Fluor, S.A., hydrofluoric acid plant, rated to have an annual consumption of 165,000 tons of fluorspar. Partly owned by Du Pont, a large fraction of Quimica Fluor's hydrofluoric acid was presumably shipped to the United States for captive usage, thereby absorbing a significant portion of the lost export market for acidspar.

Seven major producers with an annual capacity of about 1 million tons currently account for more than 80% of total production. For the most part, the fluorspar industry is Mexicanized (at least 51% Mexican ownership). Principal producing areas include the States of San Luis Potosi, Chihuahua, Coahuila, and Guanajuato. Weak market conditions notwithstanding, several of the leading producers have planned capacity expansions in coming years. In particular, Industrias Peñoles S.A., is investing $10 million to raise output at its Rio Colorado property from 110,000 tons to 300,000 tons in 1977.

Reportedly, a new flotation plant, with an initial feed capacity of 250 tons per day, came onstream towards yearend [10] in Durango, Mexico. Using crude ore from deposits in the Coneto de Comonfort area, the plant is rated to produce about 60 tons of acid-grade concentrate per day. Although undisclosed, the operator of this new facility is thought to be Minerales Productos y Metallurgicos S.A., 49% owned by Seaforth Minerals Co. of Ohio.

Previously a tax-exempt mineral commodity, fluorspar was subjected to a 7.5% export duty by the Mexican Government in early November. At yearend, the export duty was lowered to 5% in view of a worsening market condition.

Mongolia.—Mongolian production, most of which is traditionally exported to the U.S.S.R., probably topped 333,000 tons in 1976 as a result of continued expansion. A significant portion of the output came from the Berh mine in Eastern Mongolia, whose capacity has doubled in the current 5-year plan period and is expected to undergo further expansions, according to the Mongolian Soviet Nonferrous Metals Association (Mongolsovtsvetmet). Current production from the Berh mine is estimated at 150,000 annual tons, and this is expected to double in the near term.

Morocco.—Morocco's production evolved solely from one operator, Sté. Anonyme des Enterprises Minéres (Samine), an affiliate of PUK, whose fluorspar mine at El Hamman, near Meknes, increased output to 56,700 tons from 52,300 tons in 1975.

South Africa, Republic of.—Among fluorspar producing countries on the African continent, the Republic of South Africa is by far the largest, with three major companies, all subsidiaries of multinational corporations, accounting for about 80% of South African output. Principal producing areas are in Northern and Western Transvaal. In its first full year of operation, Marico Fluorspar (Pty), Ltd., a wholly owned subsidiary of the United States Steel Corp., established itself as the major fluorspar producer in South Africa. Onstream at yearend 1975, the unit is designed to produce 130,000 tons of acid-grade and 55,000 tons of metallurgical-grade fluorspar annually by 1977-78. All of Marico's production is scheduled for export to the United States and to captive consumers in

[10] Industrial Minerals. No. 111, December 1976, p. 64.

Western Europe. Largely on the strength of Marico's presence as a major new producer, South Africa's output topped 320,000 tons in 1976, up a staggering 44% from that of 1975. The most optimistic fluorspar reserve figure yet published by Gössling[11] places South African reserves at 116 million tons of ore averaging 26% CaF_2, or some 36% of known world reserves. With domestic output currently accounting for only 6% of world output, it seems likely that future exploitation of these vast reserves will ultimately make South Africa a world leader in fluorspar production.

Spain.—Although Spanish output has been gradually declining in recent times, it still ranks fourth in world prominence. Two companies, Minerales y Productos Derivados, S.A. (Minersa) and Fluoruros, S.A., accounted for about 85% of output, which totaled 324,700 tons in 1976. Principal producing areas are currently located near Aviles, Gerona, Almeria, Seville, and in the Asturias region of Northern Spain. Most of Spanish output is geared to export markets in Canada, West Germany, and the United States. Reportedly, some agglomerated material is also being made and marketed by Fluoruros.

Thailand.—In general, Thailand's fluorspar industry is fragmented and production has declined sharply in recent years, owing to a poor export market. Two foreign-owned companies, Thai Fluorspar and Minerals Co., Ltd., and Universal Mining Co., are the major producers. The main producing areas are found in the northern Provinces of Lamphun, Chiangmi, Mae Hong Song, and Lampang, and in the southern Provinces of Petchburi, Kanchanaburi, and Ratburi.

Mainly on account of severe sales reductions to Japan, production in Thailand fell from a record 471,000 tons in 1971 to 190,700 tons in 1976. Japan's waning interest in fluorspar, particularly the metallurgical variety, was due to increased usage of dolomite as a substitute flux in its steel industry. Further declines in fluorspar consumption are anticipated in 1977, and several Japanese steelmakers are understood to be negotiating with Thai, Kenyan, and Chinese suppliers for a reduction of total shipments by as much as 20%. Meanwhile, exports to the U.S.S.R. are reportedly also on the wane because Thai exporters are unable to accept barter payments in machinery and earthmoving equipment as proposed by Soviet trading agencies. As a result of this development, no fluorspar sales were made to the U.S.S.R. in the first 6 months of 1976. The outlook for a recovery in Thai production of metallurgicalfluorspar therefore appears bleak in the short term, in view of current technological trends in the Japanese steel industry and unfavorable Soviet trade policies. In contrast, acid-grade fluorspar output from the country's sole flotation plant, operated by Thai Fluorspar and Mining Co., Ltd., an affiliate of Kaiser Cement and Gypsum Corp., continued to rise, possibly attaining a record 80,000 tons in 1976. Part of Thai Fluorspar's output was shipped to the United States, and it is believed that new markets are being sought in Europe and the Middle East for the balance of its production.

At yearend, some 2,700 workers were operating 30 mines, compared with 5,200 workers and 80 mines 2 years previously, indicating clearly a disruption of an already fragmented industry structure.

Tunisia.—Tunisia's output from its sole producer, Sté. Tunisienne d'Expansion Minière (Sotemi), near Zaghouan, south of Tunis, amounted to 38,000 tons in 1976, compared with some 37,400 tons in 1975. In years past, most of Tunisian production was exported, but with the coming onstream of the Industries Chimiques du Fluor (ICF) aluminum fluoride plant at Gabes in 1976, a significant portion of domestic output will be consumed locally. Reportedly, a contract has been drawn by ICF and Sotemi for the supply of 34,000 tons of fluorspar per year.

United Kingdom.—Among fluorspar producers in the United Kingdom, Laporte Industries Ltd. is by far the largest, with mining and milling facilities near Stoney Middleton in Derbyshire. With the closing of the C. E. Giulini, Ltd. operations in Derbyshire in August 1975, annual production capacity in the United Kingdom declined by about 120,000 tons, or 29%. Further complicating the industry was the threat that Laporte's fluorspar and fluorine chemical operations could run into severe difficulties by 1977 through lack of waste disposal facilities at the Cavendish mill. A proposed new dam for tailings containment in the Peak District National Park was turned down by the Peak Park Planning Board in 1975. In May 1976 the United Kingdom Environment Secretary reversed the Board's ruling for reasons of public interest and national economy, and allowed Laporte to proceed with its project.

[11]Gössling, H. H. An Updated Summary of the World's Fluorspar Industry, 1975. National Institute for Metallurgy (Johannesburg), Rept. No. 1814, Mar. 9, 1976, 29 pp.

Meanwhile, negotiations went underway between Imperial Chemical Industries (ICI) Ltd., the parent company of Weardale Lead Co., and Swiss Aluminium Mining (United Kingdom), Ltd., the subsidiary of the Alusuisse group of Zurich, over possible collaboration in fluorspar mining and processing. A fluorspar reserve of some 800,000 tons in the Greenclough Vein in the Rookhope Valley has recently been acknowledged by Weardale Lead, which currently operates a heavy-medium and flotation plant at Rookhope using feed from its nearby Red Burn mine. Swiss Aluminium, on the other hand, is not yet a producer but has holdings in, and plans to redevelop, a number of old fluorspar mines in Durham to supply a new flotation plant to be constructed at Broadwood Quarry near Fosterly. An initial production capacity of 50,000 tons per year has been planned for the flotation plant at Broadwood Quarry, with the possibility of expanding to 175,000 at a later date.

In another industry development, British Steel Corp. has received planning permission for the construction of a fluorspar beneficiation plant at West Blackdene in Weardale, Durham.

Total fluorspar production in the United Kingdom amounted to some 260,000 tons in 1976, compared with 254,400 tons in 1975. Production is expected to increase by mid-1978 when Giulini's operations in Derbyshire are resumed by new owners.

U.S.S.R.—Despite efforts at self-sufficiency, fluorspar output from the Soviet Union remained below domestic requirements. Total production from the Maritime Kray, Transbaykal, Uzbekistan, and Kazakhstan areas is estimated at 540,000 tons, up 4% from 1975, owing to continued expansions in those areas. An additional 500,000 tons were probably imported from Mongolia, the People's Republic of China, Japan, and Thailand. To enhance the reserve base, exploration continued at the Suppatash, Kengutan, and Shabres deposits throughout 1976.

Table 10.—Fluorspar: World production, by country

(Short tons)

Country[1] and grade[2]	1974	1975	1976[p]
North America:			
Canada, acid grade[e] [3]	175,000	70,000	80,000
Mexico:			
Acid grade	[4]601,968	720,128	NA
Metallurgical grade	[4]585,381	480,085	NA
Unspecified	[5]38,692	--	--
Total	1,226,041	1,200,213	988,259
United States (shipments):			
Acid grade	77,093	56,944	116,300
Metallurgical grade	124,023	82,969	71,970
Total	201,116	139,913	188,270
South America:			
Argentina:			
Acid grade[e]	13,450	12,566	12,000
Metallurgical grade[e]	31,383	29,321	28,700
Total	44,833	41,887	40,700
Brazil, grade unspecified:[3] [6]			
Direct shipping ore (sales)	1,555	67	NA
Beneficiated product (output)	67,848	70,459	NA
Total	[r]69,403	70,526	[e]71,000
Uruguay, grade unspecified	233	72	55
Europe:			
Czechoslovakia:[3]			
Acid grade[e]	50,000	50,000	50,000
Metallurgical grade[e]	50,000	50,000	50,000
Total[e]	100,000	100,000	100,000
France:[7]			
Acid and ceramic grade[e]	[r]213,000	[r]194,000	212,000
Metallurgical grade[e]	[r]252,000	[r]157,000	179,000
Total[e]	[r]465,000	[r]351,000	391,000
Germany, East:[3]			
Acid grade[e]	25,000	25,000	25,000
Metallurgical grade[e]	75,000	75,000	75,000
Total[e]	100,000	100,000	100,000
Germany, West (marketable):[3]			
Acid grade[e]	73,531	74,051	66,796
Metallurgical grade[e]	8,170	8,228	7,428
Total[e]	81,701	[r]82,279	74,224
Greece, grade unspecified	[e]1,100	1,102	[e]1,100
Italy:[3]			
Acid grade	244,222	227,280	207,190
Metallurgical grade	29,692	27,633	25,190
Total	273,914	254,913	232,380
Romania, metallurgical grade[e] [3]	17,000	17,000	17,000
Spain:			
Acid grade	[r]278,477	278,667	244,687
Metallurgical grade	118,988	90,457	[e]80,000
Total	[r]397,465	369,124	324,687
Sweden:[3]			
Acid grade	2,470	2,065	[e]2,200
Metallurgical grade	2,021	1,689	1,700
Total	4,491	3,754	[e]3,900
U.S.S.R.:[3]			
Acid grade[e]	240,000	250,000	260,000
Metallurgical grade[e]	[r]250,000	270,000	280,000
Total[e]	[r]490,000	[r]520,000	540,000

See footnotes at end of table.

Table 10.—Fluorspar: World production, by country —Continued

(Short tons)

Country[1] and grade[2]	1974	1975	1976[p]
Europe: —Continued			
United Kingdom:[8]			
Acid grade	136,700	140,000	NA
Metallurgical and ceramic grade	39,700	36,000	NA
Unspecified	[r]80,500	78,400	NA
Total	[r]256,900	254,400	260,000
Africa:			
Egypt, grade unspecified	1,236	[e]1,300	[e]1,300
Kenya, metallurgical grade[3]	[r]42,400	60,200	82,703
Morocco, grade unspecified	20,999	52,273	56,714
Rhodesia, Southern, metallurgical grade[e 3]	200	200	220
South Africa, Republic of:			
Acid grade	213,369	189,895	232,449
Ceramic grade	5,499	11,347	43,543
Metallurgical grade	10,338	22,067	44,469
Total	229,206	223,309	320,461
Tunisia, acid grade	31,215	37,387	38,030
Zambia	507	[r e]110	3
Asia:			
Burma, metallurgical grade	[e]220	--	--
China, People's Republic of, metallurgical grade[e 3]	330,000	385,000	385,000
India:			
Acid grade	5,196	5,469	NA
Metallurgical grade	6,608	5,794	NA
Total	11,804	11,263	[e]11,000
Korea, North, metallurgical grade[e 3]	[r]33,000	[r]33,000	33,000
Korea, Republic of, metallurgical grade	36,355	31,191	22,344
Mongolia, metallurgical grade[e 3]	275,000	[r]333,000	[e]333,000
Pakistan, grade unspecified	[r]75	12	11
Thailand:			
Acid grade[9]	60,580	76,631	49,490
Metallurgical grade[10]	375,623	192,814	141,183
Total	436,203	269,445	190,673
Turkey, metallurgical grade	[e]2,200	1,549	[e]1,700
Oceania: Australia, grade unspecified	262	([11])	--
Grand total	[r]5,355,079	5,015,422	4,888,734

[e]Estimate. [p]Preliminary. [r]Revised. NA Not available.

[1]In addition to the countries listed, Bulgaria is believed to have produced fluorspar, but production is not officially reported and available information is inadequate for the formulation of reliable output level estimates.

[2]An effort has been made to subdivide production of all countries by grade (acid, ceramic, and/or metallurgical). Where the subdivision is available in offical reports of the subject country, the data have been entered without qualifying notes; where a secondary source has been used to subdivide production by grade, the source of the information for this subdivision has been identified by footnote. Where no basis for subdivision is available, the country entry has been identified with the notation "grade unspecified."

[3]Information on grade obtained from Bundesanstalt Für Bodenforschung Hannover and Deutsches Institut Für Wirtschaftsforschung Berlin. Untersuchungen über Angebot und Nachfrage Mineralischer Rohstoffe IV. Flusspat, March 1974, p. 39.

[4]Exports.

[5]Figures represent the difference between reported exports (divided by grade) and total production (reported without differentiation by grade), and presumably are domestic consumption plus or minus changes in stocks of both acid and metallurgical grade.

[6]Data for Brazil exclude some crude ore mined, but neither sold as direct-shipping ore nor beneficiated during year specified. Total crude ore production follows in short tons: 1974—116,705, 1975—120,346, 1976—NA. Of this output, crude ore beneficiated totaled as follows in short tons: 1974—97,044, 1975—120,532, 1976—NA; producers' initial stocks (as of January 1) totaled as follows in short tons: 1974—3,167, 1975—[r]10,777, 1976—NA; producers' yearend stocks totaled as follows in short tons: 1974—11,704, 1975—10,524, 1976—NA; and transfers totaled as follows in short tons: 1974—9,568, 1975—zero, 1976—NA. The acid-grade fluorspar reported in last year's chapter has been eliminated since no information is available on output.

[7]Figures reported represent marketable production (the summation of direct-shipping ore and finished concentrates). Total run-of-mine production (direct-shipping ore plus ore destined for concentration) follows in short tons: 1974—761,000, 1975—805,000, 1976—744,000. Much of this material requires beneficiation before it becomes a salable product.

[8]Includes materials recovered from lead-zinc mine dumps.

[9]Figures presented are the calculated salable acid-grade fluorspar equivalent of officially reported actual mine production of flotation plant feedstock reported in Thai sources as "low grade ore," which were as follows in short tons: 1974—[r]96,927, 1975—122,611, 1976—79,184. In 1976, flotation plant output reportedly reached a record high, apparently as a result of the processing of material mined previously but not processed when mined.

[10]Figures presented are officially reported mine production of high-grade ore.

[11]Estimate revised to zero.

Table 11.—Fluorspar: World trade[1] by source and destination, 1975

(Short tons)

Source	Destination								
	Australia[2]	Austria	Belgium-Luxembourg	Canada	France	Germany, West	Italy	Japan	Netherlands
Argentina	--	--	--	--	--	--	--	--	--
Austria[3]	--	XX	--	--	--	--	--	--	--
Belgium-Luxembourg[3]	--	--	XX	--	--	--	--	--	(4)
Brazil	--	--	--	--	--	--	--	6,063	--
Canada	--	--	--	XX	--	--	--	--	--
China, People's Republic of	8,066	--	--	--	--	--	--	116,278	(4)
France	--	441	4,489	--	XX	[4]79,009	14,520	--	463
Germany, East	--	8,896	2,111	--	--	--	--	--	(4)
Germany, West	--	6,016	2,793	--	1,864	XX	57	--	685
Italy	--	387	--	10,206	3,194	27,284	XX	--	--
Japan	--	--	--	--	--	--	--	XX	--
Kenya	--	--	--	--	--	--	--	17,060	--
Korea, North	--	--	--	--	--	--	--	1,002	--
Korea, Republic of	--	--	--	--	--	--	--	12,052	--
Mexico	--	--	--	103,655	--	1,109	19,058	--	--
Mongolia	--	--	--	--	--	--	--	--	--
Morocco	--	--	--	--	11,540	--	--	--	--
Mozambique	--	--	--	--	--	5,971	--	--	--
Netherlands[3]	--	--	--	--	--	--	--	--	XX
South Africa, Republic of	16,941	--	--	--	--	6,759	--	78,928	(4)
Spain	--	--	--	51,347	--	63,720	--	--	[5]6,780
Sweden	--	--	--	--	--	--	--	--	(4)
Switzerland[3]	--	250	--	--	--	--	--	--	(4)
Thailand	8,512	--	--	--	--	--	--	163,064	[5]1,102
Tunisia	--	--	--	--	--	--	6,121	--	(4)
Turkey	--	--	--	--	--	1,009	--	--	(4)
United Kingdom	240	--	--	3,118	946	22,397	--	202	(4)
United States	--	--	--	22,713	--	--	--	--	--
Unspecified and other	1	30	639	--	191	80,547	--	4,939	16,689
Total	33,760	16,020	10,032	191,039	17,735	287,805	39,756	399,588	25,719

Source	Destination							Total receipts by listed countries	Total recorded exports
	Norway	Poland	Sweden	U.S.S.R.	United States	Yugoslavia	Other[6]		
Argentina	--	--	--	(4)	--	--	2,209	2,209	2,242
Austria[3]	--	--	--	(4)	--	56	--	56	--
Belgium-Luxembourg[3]	--	--	--	(4)	--	--	--	--	378
Brazil	--	--	--	(4)	10,676	--	--	16,739	12,208
Canada	--	--	--	(4)	16,839	--	--	16,839	[e]16,850
China, People's Republic of	561	21,464	3,793	61,076	--	--	518	211,756	[e]220,000
France	--	--	7,918	(4)	6,842	499	901	115,082	120,523
Germany, East	7,053	23,223	2,364	(4)	--	4,016	541	48,204	[e]50,000
Germany, West	5,221	--	68	(4)	--	2,321	6,059	25,084	23,066
Italy	--	--	50	12,380	34,814	66	2,678	91,059	93,053
Japan[3]	--	--	--	--	--	--	1,723	1,723	--
Kenya	--	--	--	--	11,618	--	--	28,678	[7]54,193
Korea, North	--	4,795	--	(4)	--	--	77	5,874	[e]6,000
Korea, Republic of	--	--	--	(4)	--	--	4,354	16,406	11,828
Mexico	--	--	--	--	793,832	--	169	917,823	924,804
Mongolia	--	--	--	332,687	--	--	--	332,687	333,000
Morocco	--	--	--	(4)	5,824	--	--	17,364	32,292
Mozambique	--	--	--	(4)	--	--	--	5,971	--
Netherlands[3]	--	--	--	(4)	--	--	28	28	[8]72
South Africa, Republic of	--	--	123	(4)	18,701	--	--	121,452	139,502
Spain	10,979	--	--	(4)	126,477	--	2,757	262,060	247,250
Sweden	76	--	XX	(4)	--	--	28	104	420
Switzerland[3]	--	--	--	(4)	--	248	4,467	4,965	[7]419

See footnotes at end of table.

Table 11.—Fluorspar: World trade[1] by source and destination, 1975 —Continued

(Short tons)

Source	Destination							Total receipts by listed countries	Total recorded exports
	Norway	Poland	Sweden	U.S.S.R.	United States	Yugoslavia	Other[6]		
Thailand	--	--	--	64,462	17,543	--	11,504	266,187	233,358
Tunisia	--	--	--	([4])	7,282	--	--	13,403	[7]13,283
Turkey	--	--	--	([4])	--	--	--	1,009	--
United Kingdom	27,015	--	401	([4])	--	110	2,362	56,791	[e]90,000
United States	--	--	--	33,747	XX	--	776	57,236	1,355
Unspecified and other	--	265	6	40,068	--	--	14	143,389	NA
Total	50,905	49,747	14,723	544,420	1,050,448	7,316	41,165	2,780,178	2,626,096

[e]Estimate. XX Not applicable.

[1]Compiled from official import data of listed countries of destination except where otherwise specified by footnote; figures in total receipts by listed countries column are simply summations of reported imports for all listed destinations, in contrast to figures in total recorded exports column which are either (1) actual reported exports of listed source countries or (2) estimates of total exports. Differences between these two columns are attributed to (1) time lag between date of shipment and date of receipt, (2) concealment policies of some countries, and (3) reshipment of material by intermediate countries which may be credited as the origin in the trade returns of the final destination countries.

[2]Imports for year beginning July 1, 1974.

[3]No recorded production of fluorspar; exports are generally derived from imported materials.

[4]A substantial part of total imports are not distributed by destination; such undistributed imports may have originated in any country carrying the footnote and/or in other nations not specifically listed in the first column of this table.

[5]Official import statistics show no receipts from this country, but do include a substantial quantity of material from undisclosed sources. Figure entered here represents reported export of source country to this destination. (An equal amount has been substracted from the destination country's reported import from undisclosed sources).

[6]Data compiled from official import statistics of 10 nations and export statistics of 6 significant producing nations, the latter to determine apparent imports for 13 other countries for which official fluorspar import figures are not available. Nations reporting imports and total recorded imports for each are as follows in short tons: Denmark—3,179; Finland—4,834; India—4,636; the Republic of Korea—7,420; Mexico—less than 1/2 unit; Spain—10; Taiwan—8,745; Thailand—14; Turkey—176; and Venezuela—520. Nations for which apparent imports have been derived and apparent imports for each are as follows in short tons: West Germany—6,059; Italy—2,678; the Republic of Korea—4,354; Mexico—169; Spain—2,757; and Thailand—11,504.

[7]Figure includes fluorspar as well as any feldspar, nepheline, and/or nepheline syenite exported.

[8]Excludes trade between the Netherlands and Belgium-Luxembourg.

WORLD CONSUMPTION

World consumption of fluorspar in the aluminum and steel industries can generally be estimated with some degree of accuracy, but consumption in other end uses, notably fluorocarbons, is more difficult to estimate owing to scarcity of data.

As in the United States, consumption of fluorspar in the steel industries around the world varies according to furnace types and among individual furnaces. On the average, it is estimated that open hearth furnaces account for about 4.0 pounds of fluorspar per ton of crude steel; basic oxygen furnaces, 11.4 pounds per ton; and electric furnaces, 8.9 pounds per ton. While figures are not yet available for the division of steel production by process in 1976, it would appear from the International Iron and Steel Institute data for 1974 that 62% of total output from 24 reporting countries came from basic oxygen furnaces, 19% from electric furnaces, 16% from open hearth furnaces, and the balance from other types of furnaces. Thus, with the exception of the United States and Japan, free world consumption of fluorspar is estimated at 8.5 pounds per ton of raw steel on the average. In the United States an average consumption of 9.5 pounds per ton was reported. Japanese consumption, on the other hand, has continually been on the decline, owing largely to improved smelter technology and the use of substitute fluxes, particularly dolomite. It is probable that overall consumption in Japanese steel furnaces is about 4.0 pounds per ton, and it may be as low as 2.0 pounds per ton in 1977. In contrast, 65% of crude steel output from central economy countries is believed to evolve from open-hearth furnaces, 24% from basic oxygen furnaces, 10% from electric furnaces, and the remainder from other types of furnaces. Thus, it appears likely that fluorspar consumption in the steel industries of these countries may average about 6.6 pounds per ton of crude steel.

Estimated fluorspar consumption in the steel industries worldwide amounted to 2.73 million tons in 1976, compared with 2.56 million tons in 1975, (table 12), reflecting a general recovery in steel production. The United States and the U.S.S.R. continued as major consumers, accounting for 22% and 19%, respectively, of total consumption in this end use, followed by Japan (9%) and West Germany (7%).

The next major end use of fluorspar, particularly the acid-grade variety, is in the aluminum industry. In most countries, it is assumed that fluorspar is first converted into hydrofluoric acid, and subsequently into aluminum fluoride and synthetic cryolite. Based on current estimates, aluminum potlines around the world consume an average of 130 pounds of fluorspar per ton of primary aluminum produced.

Fluorspar consumption in the aluminum smelters worldwide is estimated at some 880,700 tons in 1976, up 3% from an estimated 854,300 tons in 1975, (table 13). As in the case of steel, major consuming countries were the United States and the U.S.S.R., accounting for 30% and 13%, respectively, of the total consumed in this category, followed by Japan (7%) and West Germany (6%).

Fluorspar consumption in fluorocarbon manufacture and other end use categories, while representing a significant portion of overall consumption, is not susceptible to close accounting owing to scarcity of data. It is generally believed, however, that the United States produces about half the world's supply of fluorocarbons and possesses half the world's installed uranium-enrichment capacity. These generalizations provide the basis for the estimates shown in table 14. Fluorocarbon production dropped slightly in 1976, and recovery is not anticipated in coming years in the face of environmental concerns over its usage. Consequently, acidspar demand in this end use is expected to exhibit a downturn in the short run, pending unfavorable legislation on fluorocarbon usage. On the other hand, fluorspar requirements in uranium enrichment are expected to expand by as much as 15% as nations develop alternative sources of nuclear energy to supplement energy from petroleum. Estimates of fluorspar consumption in petroleum alkylation, stainless steel pickling, glass and enamels, foundries, and miscellaneous other end uses are educated guesses and should be interpreted with caution.

Overall, world consumption of fluorspar in all categories is estimated at 4.57 million tons in 1976, compared with 4.41 million tons in 1975, reflecting a general recovery in the aluminum and steel industries. Steel production accounted for 60% of total consumption, followed by aluminum production (19%) and fluorocarbons (15%). Uranium enrichment, petroleum alkylation, stainless steel pickling, glass and enamels, foundries, and miscellaneous other end use categories accounted for the remaining 6% of total consumption.

Table 12.—Estimated world production of crude steel and fluorspar consumption

	Steel production (thousand short tons)		Fluorspar consumption (short tons)	
	1975	1976	1975	1976
North America:				
Canada	14,357	14,480	61,017	61,540
United States	116,642	128,000	519,630	606,578
Latin America:				
Argentina	2,500	2,657	10,625	11,292
Brazil	9,158	10,135	38,921	43,074
Mexico	5,812	5,840	24,701	24,820
Venezuela	1,185	1,033	5,036	4,390
Others[1]	1,716	1,617	7,293	6,872
Western Europe:				
Austria	4,484	4,935	19,057	20,974
Belgium	12,773	13,392	54,285	56,916
Finland	1,784	1,812	7,582	7,701
France	23,733	25,596	100,865	108,783
Germany, West	44,550	46,754	189,337	198,704
Italy	24,070	25,845	102,297	109,841
Luxembourg	5,098	5,033	21,666	21,390
Netherlands	5,289	5,701	22,478	24,229
Norway	1,000	990	4,250	4,207
Spain	12,253	12,024	52,075	51,102
Sweden	6,186	5,666	26,290	24,080
United Kingdom	22,264	24,552	94,622	104,346
Others[2]	2,732	2,852	11,611	12,121
Africa:				
South Africa, Republic of	7,163	7,807	30,443	33,180
Others[3]	1,212	1,351	5,151	5,742
Australia and Asia:				
Australia	8,645	8,569	36,741	36,418
India	7,807	10,429	33,180	44,323
Japan	112,780	118,387	225,560	236,774
Korea, Republic of	2,215	2,974	9,414	12,639
Turkey	1,607	1,601	6,830	6,804
Others[4]	2,804	2,999	11,917	12,746
Total, market economy countries	461,819	493,031	1,732,874	1,891,586
Central economy countries:				
Bulgaria	2,497	2,712	8,240	8,950
China, People's Republic of	32,000	30,000	105,600	99,000
Czechoslovakia	15,789	16,196	52,104	53,447
Germany, East	7,135	7,430	23,545	24,519
Hungary	4,049	4,026	13,362	13,286
Korea, North	3,200	3,300	10,560	10,890
Poland	16,542	17,240	54,589	56,892
Romania	10,526	11,905	34,736	39,286
U.S.S.R	155,784	159,620	514,087	526,746
Yugoslavia	3,215	3,032	10,609	10,006
Total, central economy countries	250,737	255,461	827,432	843,022
Grand total	712,556	748,492	2,560,306	2,734,608

[1]Includes Cuba, Chile, Colombia, El Salvador, Peru, and Uruguay.
[2]Includes Denmark, Greece, Ireland, Portugal, and Switzerland.
[3]Includes Algeria, Egypt, Morocco, Southern Rhodesia, Tunisia, and Uganda.
[4]Includes Bangladesh, Burma, Hong Kong, Iran, Indonesia, Israel, Lebanon, Malaysia, Philippines, Singapore, Taiwan, Thailand, and New Zealand.

Source of data on steel: U.S. Bureau of Mines.

Table 13.—Estimated world production of primary aluminum and fluorspar consumption

	Aluminum production (thousand short tons)		Fluorspar consumption (short tons)	
	1975	1976	1975	1976
North America:				
Canada	978	690	63,570	44,850
United States	3,879	4,251	238,558	261,800
Latin America:				
Argentina	26	50	1,690	3,250
Brazil	134	149	8,710	9,685
Mexico	44	47	2,860	3,055
Surinam	49	51	3,185	3,315
Venezuela	64	55	4,160	3,575
Western Europe:				
Austria	98	98	6,370	6,370
France	422	424	27,430	27,560
Germany, West	747	768	48,555	49,920
Greece	149	148	9,685	9,620
Iceland	68	72	4,420	4,680
Italy	210	228	13,650	14,820
Netherlands	288	282	18,720	18,330
Norway	656	670	42,650	43,550
Spain	234	236	15,210	15,340
Sweden	85	90	5,525	5,850
Switzerland	87	86	5,655	5,590
United Kingdom	340	369	22,100	23,985
Africa:				
Cameroons	57	63	3,705	3,965
Egypt	2	61	130	3,965
Ghana	158	162	10,270	10,530
South Africa, Republic of	84	86	5,460	5,590
Australia and Asia:				
Australia	236	256	15,340	16,640
Bahrain	128	135	8,320	8,775
India	184	234	11,960	15,210
Iran	56	34	3,640	2,210
Japan	1,117	1,013	72,605	65,845
Korea, Republic of	20	19	1,300	1,235
New Zealand	120	154	7,800	10,010
Taiwan	31	28	2,015	1,820
Turkey	18	39	1,170	2,535
Total, market economy countries	10,769	11,048	686,418	703,475
Central economy countries:				
China, People's Republic of	180	220	11,700	14,300
Czechoslovakia	48	55	3,120	3,575
Germany, East	65	65	4,225	4,225
Hungary	77	78	5,005	5,070
Poland	113	110	7,345	7,150
Romania	225	220	14,625	14,300
U.S.S.R	1,690	1,760	109,850	114,400
Yugoslavia	185	218	12,025	14,170
Total, central economy countries	2,583	2,726	167,895	177,190
Grand total	13,352	13,774	854,313	880,665

Source of data on aluminum: U.S. Bureau of Mines.

Table 14.—Estimated world consumption of fluorspar in the chemical and other sectors

(Short tons)

	1975	1976
Fluorocarbons	746,000	690,000
Uranium enrichment	40,000	45,000
Petroleum alkylation	50,000	53,000
Stainless steel pickling	40,000	42,000
Glass and enamel	30,000	32,000
Foundries	40,000	40,000
Miscellaneous	50,000	50,000
Total	996,000	952,000

TECHNOLOGY

Following the publication in 1974 of the Molina and Rowland theory suggesting that fluorocarbons could cause a depletion of stratospheric ozone,[12] many investigations were initiated to verify the theory. Results of these independent studies have recently been released by the National Academy of Sciences, the Environmental Protection Agency,[13] the Manufacturing Chemists Association,[14] the United Kingdom Department of the Environment,[15] and the United Kingdom Atomic Energy Authority.[16] Although estimates vary as to the extent of ozone depletion that can be attributed to fluorocarbon releases within certain time frames, the consensus appears to be that fluorocarbons are a legitimate cause for environmental concern.

The search for less-energy-intensive method of aluminum production led to the revolutionary Alcoa Smelting Process, implemented at midyear in a newly built smelter in Palestine, Tex. Based on the electrolysis of aluminum chloride, to which minor amounts of lithium chloride and sodium chloride are added, the process is expected to reduce power requirements to 5 kilowatt-hours per pound of aluminum, compared with 6.5 kilowatt-hours per pound in today's most efficient conventional smelters. Since no fluorides are used in the process, its impact on the fluorspar industry may be far reaching should it prove successful and be adopted in new smelters worldwide.

The Bureau of Mines continued its research into byproduct fluosilicic acid recovery from phosphate rock. Using phosphoric acid as an acidulating-defluorinating medium, it has been demonstrated that over 80% of the fluorine can be evolved and recovered as a dilute solution of fluosilicic acid. Meanwhile, new processes have been developed in the United Kingdom, Ireland, and West Germany for the conversion of fluosilicic acid into synthetic fluorspar and anhydrous hydrofluoric acid.[17]

In the Republic of South Africa, Gössling[18] investigated the feasibility of pelletizing acid-grade concentrates. Tests have shown that pellets of 95% effective CaF_2, with 0.5% sodium silicate as a binder, can be economically produced for export to the United States and Western Europe. In a separate report, Simonsen and Levin[19] discuss the beneficiation of a complex ore containing fluorspar, dolomite, and pyrophyllite, with minor amounts of quartz, muscovite, and chloritic and ferruginous material.

According to van Alstine,[20] major fluorspar districts are localized chiefly along and near continental rift zones and lineaments. This association of major fluorspar districts with continental rifts and lineaments is regarded as a regional guide in the search for new fluorspar deposits.

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[13]U.S. Environmental Protection Agency. Environmental Hazard Assessment Report. Major One-and-Two Carbon Saturated Fluorocarbons. Review of Data. August 1976, 159 pp.

[14]Manufacturing Chemists Association. The Effect of Fluorocarbons on the Concentration of Atmospheric Ozone. Mar. 16, 1976, 133 pp.

[15]United Kingdom Department of the Environment. Cholorofluorocarbons and Their Effect on Stratospheric Ozone. 1976, 71 pp.

[16]Cox, R. A., Derwent, R. G., and Eggleton, A. E. J. Chlorine Nitrate - a Possible Stratospheric Sink for Cl0 Radicals and NO_x With Significant Implication for Ozone Depletion. United Kingdom Atomic Energy Authority, May 1976, 10 pp.

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[17]Phosphorus and Potassium. New Possibilites for Conversion of Recovered Fluosilicic Acid. No. 85, September/October 1976, pp. 38-42.

[18]Gössling, H. H. An Economic Assessment of the Production of High-Grade Fluorspar Pellets. National Institute for Metallurgy (Johannesburg), Rept. No. 1660, June 1976, 13 pp.

[19]Simonsen, H. A., and Levin, J. Concentration of Fluorspar From the Farm Strydfontein, Marico District. Preliminary Investigation. National Institute for Metallurgy (Johannesburg), Rept. No. 77, August 1976, 12 pp.

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Gallium

By Benjamin Petkof[1]

The domestic gallium industry increased both production and production capacity during 1976. Data on rest-of-world production and consumption were not available. U.S. imports of gallium declined. Most gallium consumption continued to be in the production of various gallium compounds used to produce gallium-based electronic devices.

Legislation and Government Programs.—Gallium was classified by the Materials Transportation Bureau, U.S. Department of Transportation, as a hazardous material for purposes of transportation, and regulations were published in the Federal Register (September 2, 1976), effective September 4, 1976, specifying materials for the inner and outer packaging of gallium shipments. Gallium must be in the solid state during the time of transportation.

Table 1.—Salient gallium statistics in the United States

(Kilograms)

	1973	1974	1975	1976
Production	W	W	W	W
Imports for consumption	11,124	6,536	6,830	4,920
Consumption	8,496	6,939	7,493	8,880
Price per kilogram	$750	$750	$750-$800	$750-$800

W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Domestic gallium production remained strong in 1976 and was estimated to have increased over that of 1975. Two companies with three facilities recovered metallic gallium in 1976. The Aluminum Co. of America (Alcoa), using proprietary gallium production technology at its Bauxite, Ark., alumina plant, recovered gallium as a coproduct from residues of its alumina production process. In addition, at midyear Alcoa announced the commencement of gallium recovery at its Mobile, Ala., alumina plant. Eagle-Picher Industries, Inc., continued to produce gallium metal, oxide, and trichloride from zinc production residues at its Quapaw, Okla., facility. Canyonlands 21st Century Corp. reprocessed gallium from gallium arsenide at its plant in Blanding, Utah. Other domestic companies produced high-purity gallium metal and gallium compounds such as arsenide, oxide, phosphite, and trichloride for the manufacture of electronic devices.

CONSUMPTION

Total domestic gallium consumption increased almost 19% over that of 1975. Electronic usage increased almost 12% and consumption for research and development increased more than sixfold. The quantity of metal used to prepare dental alloys declined significantly. The bulk of the gallium was consumed for the manufacture of electronic devices such as light-emitting diodes and other semiconductor devices. Most of the gallium used was high-purity metal. Gallium in the form of intermetallic

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compounds such as arsenide, phosphide, and arsenide-phosphide was also used for the manufacture of light-emitting diodes and semiconductor devices. Gallium oxide was used for the preparation of phosphors.

The general acceptance of devices such as solid state calculators, digital clocks and watches, and visual display instrumentation using gallium-based components helped sustain the demand for gallium. Interest in the development of gallium-based solar-cells for the production of electricity and the use of gallium-based, light-emitting diodes as a source of light energy for transmission along fiber-optic cables may also stimulate future demand for gallium.

Table 2.—Consumption of gallium, by end use

(Grams)

End use	1975	1976
Alloys[1]	7,050	4,025
Electronics[2]	7,338,100	8,209,931
Research and development	91,156	608,994
Unspecified uses	56,500	57,000
Total	7,492,806	8,879,950

[1]Specialty alloys.
[2]Light-emitting diodes, semiconductors, and other electronic devices.

STOCKS

Consumer stocks of gallium metal at yearend 1976, both commercial and high-purity grades, shown in table 3, increased 83% over beginning stocks.

Table 3.—Stocks, receipts, and consumption of gallium

(Grams)

Purity	Beginning stocks[1]	Receipts	Consumption	Ending stocks[1]
1975:				
97.0%-99.9%	18,379	--	9,137	9,242
99.99%	3,591	3,054	3,468	3,177
99.999%	5,478	57,162	59,931	2,709
99.9999%-99.99999%	521,744	7,807,980	7,420,270	909,454
Total	549,192	7,868,196	7,492,806	[2]924,582
1976:				
97.0%-99.9%	9,242	2,657	5,536	6,363
99.99%	3,177	675	1,426	2,426
99.999%	2,709	68,355	59,827	11,237
99.9999%-99.99999%	[2]912,274	9,574,992	8,813,161	1,674,105
Total	[2]927,402	9,646,679	8,879,950	1,694,131

[1]Consumers only.
[2]Ending stocks for 1975 do not equal 1976 beginning stocks because of reported beginning stock adjustments.

PRICES

Prices paid for gallium are not reported and are subject to negotiation between buyer and seller. However, during 1976 the American Metal Market quoted metal of 99.999% purity at $750 to $800 per kilo in 100-kilogram lots.

FOREIGN TRADE

Data on exports of gallium minerals are not reported separately but are included in the category "base metals and alloys, not elsewhere classified, wrought or unwrought, waste and scrap." Significant quantities of gallium and gallium compounds are probably exported in the form of manufactured gallium-based electronic components and equipment.

Total U.S. imports of gallium declined 28% in quantity and 35% in value from those of 1975. West Germany and Switzerland supplied 85% of these imports. The average value of imports was $473 per kilo.

Table 4.—U.S. imports for consumption of gallium (unwrought, waste and scrap), by country

Country	1975		1976	
	Kilograms	Value	Kilograms	Value
Canada	242	$129,745	214	$100,706
China, People's Republic of	--	--	50	19,633
Czechoslovakia	5	1,400	--	--
Germany, West	--	--	2,391	1,103,652
Hungary	--	--	199	66,890
Italy	254	100,512	75	27,210
Japan	42	64,000	50	70,115
Netherlands	269	147,920	40	21,078
Switzerland	6,001	3,103,364	1,799	873,854
United Kingdom	17	8,414	90	40,319
U.S.S.R	--	--	12	2,719
Total	6,830	3,555,355	4,920	2,326,176

WORLD REVIEW

World production and consumption data for gallium are not available. It is believed that significant quantities of gallium metal and compounds are consumed by countries with large, well-developed electronic and electrical industries. It is also thought that production of gallium declined in countries other than the United States.

TECHNOLOGY

A technique was described to successfully etch polish gallium phosphide single crystals using an aqueous solution of chlorine.[2]

A process was patented whereby gallium was extracted from sodium aluminate liquor formed in processing bauxite by the Bayer process. The liquor was cooled to about 60° C to precipitate the soda. The purified liquor was mixed with additional mother liquor and contacted with a liquid gallium-aluminum alloy to cause cementation of gallium from the liquor. The gallium was then recovered.[3]

[2]Milch, A. Etch Polishing of GaP Single Crystals by Aqueous Solutions of Chlorine and Iodine. J. Electrochem. Soc., v. 123, No. 8, August 1976, pp. 1256-1257.

[3]Shalavina, E. L., et al. Extraction of Gallium Values From Sodium Aluminate Liquor. U.S. Pat. 3,988,150, Oct. 26, 1976.

Gem Stones

By W. Timothy Adams[1]

The production value of gem stones and mineral specimens in the United States during 1976 was estimated to be $8.9 million, an increase of 2% over that of 1975. Most of the value was contributed by the few companies that operated deposits for emerald, jade, opal, sapphire, and turquoise. Amateur collectors were important even though their total contribution was surpassed by the commercial operators. The commercial operators sold mainly to wholesale or retail outlets and occasionally to jewelry manufacturers.

DOMESTIC PRODUCTION

Mines and collectors in 39 States produced gem materials estimated at $1,000 or more for each State. Ten States supplied 90% of the total value as follows: Arizona, $4.0 million; Nevada, $1.3 million; Maine, $1.1 million; Oregon, $525,000; California, $231,000; New Mexico, $210,000; Montana, $170,000; Texas, $168,000; Washington, $168,000; and Wyoming, $147,000.

Park authorities at the Crater of Diamonds Park in Arkansas reported the finding of 398 diamonds, of which 1 was 3 carats and 3 were 2 carats each. No value was placed on the stones.[2]

A report was published on the evaluation of diamond-containing weathered kimberlite pipes in Colorado and Wyoming.[3]

A 200-carat emerald crystal was found at the Big Crabtree emerald mine near Little Switzerland, N.C. The stone appeared to be of fine quality and could yield a stone of 40 carats if cut. It would be larger than the Carolina emerald of 14 carats. Peridot was mined by about 200 individuals of the San Carlos Apache Tribe at Peridot, Ariz., and no estimate of quantity and value of the peridot was available.

The production of turquoise of all grades and quantities reported was 221 tons, valued at $3.9 million and was principally from Arizona, Nevada, and Colorado. The great interest in Native American style jewelry continued throughout 1976. Many articles appeared in various publications describing the qualities of genuine turquoise and Native American jewelry.[4]

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[1]Physical scientist, Division of Nonmetallic Minerals.

[2]Arkansas Department of Parks and Tourism, Parks Division.

[3]McCallum, M. E. and C. D. Mabarak. Diamond in State-Line Kimberlite Diatremes, Albany County, Wyo.; Larimer County, Colo., Geol. Survey of Wyo., RI 12, September 1976, 36 pp.

[4]Hass, L. N. Turquoise — Blue Heaven in a Stone, Part I. Gems and Miner., No. 458, December 1975, pp. 8-9, 62-63, 76-77.

———. Part II. Gems and Miner., No. 459, January 1976, pp. 42, 62-64.

———. Part III. Gems and Miner., No. 460, February 1976, pp. 33-36.

Rowe, R. C. Turquoise — Genuine or False. Gems and Miner., No. 459, January 1976, pp. 35-37.

Hemrich, G. I. Turquoise Substitutes. Gems and Miner., No. 470, December 1976, pp. 17-20, 22.

Mine	Location	Operator
Emerald: Big Crabtree mine	Mitchell County, N.C	PBH Emerald Co. Box 163 Little Switzerland, N.C. 28749
Jade: Stewart Jewel Jade mine	Kobuk Village, Alaska	Stewart Jewel Jade Co. 531 4th Ave. Anchorage, Alaska 99501
Opal:		
Royal Peacock mine	Humboldt County, Nev	Harry W. Wilson Denio, Nev. 89404
Spencer Opal mine (dig-for-fee mine).	Clark County, Idaho	Mark L. Stetler 1862 Ranier St. Idaho Falls, Idaho 83401
Sapphire:		
Chaussee Sapphire mine (sold unscreened material to tourists in summer and assisted in screening).	Granite County, Mont	Chaussee Sapphire Corp. Box 706 Philipsburg, Mont. 59858
Sapphire Village mine (Yogo Gulch).	Judith Basin County, Mont.	Sapphire International Corp. Box 30 Utica, Mont. 59452
Turquoise:		
Aurora mine	Lander County, Nev	Carico Lake Mining Co. Box 3426 Albuquerque, N. Mex. 87110
Black Spider mine	do	Grillos Mining Co. 2221 10th St. Lubbock, Tex. 79401
Blue Eagle mine	Mineral County, Nev	E. Loving and D. Lester Box 155 Mina, Nev. 89422
Blue Jim mine	Lander County, Nev	James Elquist Box 255 Battle Mountain, Nev. 89820
Blue Spider mine	do	John Lee & Co. 5101 North 40th St., Apt. 119 Phoenix, Ariz. 85018
Boundary mine	Mineral County, Nev	D. Brannon and R. H. Herrington Box 377 Mina, Nev. 89422
Duval Corp. mine	Mohave County, Ariz	L. W. Hardy Co., Inc. 3809 East Highway 66 Kingman, Ariz. 86401
Morenci mine	Greenlee County, Ariz	W. O. Brown 230 West 66 Ave. Gallup, N. Mex. 87301
Pinto Valley mine	Gila County, Ariz	L. W. Hardy Co., Inc. 3809 East Highway 66 Kingman, Ariz. 86401
Red Mountain mine	Lander County, Nev	J. M. Johnson 102 West 9th Pl. Mesa, Ariz. 85201 Turquoise Nugget (colessee) Box 1118 Flagstaff, Ariz. 86001
Royal Blue mine	Esmeralda County, Nev	R. C. Wilcox Box 1311 Tonopah, Nev. 89040
Shoshone and Ackerman mines	Churchill County, Nev	Lombardo Turquoise Co., Inc. 1300 East Main St. Austin, Nev. 89310
Turquoise Chief mine	Lake County, Colo	N. F. Reed Albuquerque, N. Mex. 87110
Villa Grove mine	Saguache County, Colo	G. Musick Box 174 Villa Grove, Colo. 81155

CONSUMPTION

Domestic gem stone output went to amateur and commercial rock, mineral, and gem stone collections, objects of art, and jewelry. Apparent consumption of gem stones (domestic production plus imports minus exports and reexports) was $705 million, 51% more than that of 1975.

PRICES

Typical costs to a retail jeweler in December 1976 for representative better quality gem stones as reported by 15 typical importers were as follows:[5]

[5]Jewelers' Circular — Keystone. JC-K's Colored Stone Price Index. V. 147, No. 5, February 1977, p. 84.

Gem stone	Carat weight	Median price per carat	Price range per carat
Amethyst	10	$15	$11-$17.50
Aquamarine	8	120	75-260
Cat's eye	5	1,100	750-1,100
Citrine	10	8	5-10
Emerald	1	2,875	1,500-5,000
Garnet, green	1	475	400-600
Man's sky blue star	10	300	190-450
Opal, black	3	438	300-500
Opal, white, fiery	5	62	60-70
Peridot	10	50	45-60
Ruby	2	1,875	1,250-3,500
Sapphire	2	725	400-1,200
Tanzanite	5	300	150-250
Tourmaline, green	10	55	55-100
Tourmaline, pink	10	100	75-125

NOTES.—Ten-carat cat's eyes and 15-carat peridot, both of which were on the 1974 list, became unavailable during 1975, but the median price per carat of the smaller stones held at the levels of the larger stones.

No survey was made of diamond prices; price trends indicated higher prices for cut diamond 1 carat and smaller, but no change in larger cut diamond.

FOREIGN TRADE

Exports of all gem materials amounted to $326.7 million, and reexports to $155.5 million. Diamond accounted for 94% of the value of exports and 92% of the reexports. Exports of diamond totaled 312,853 carats valued at $306.1 million. Of this total, diamond cut but unset, suitable for gem stones not over 0.5 carat, was 53,375 carats valued at $21.1 million; and cut, but unset, over 0.5 carat was 258,738 carats valued at $284.9 million.

Reexports of diamond amounted to 1,198,805 carats, valued at $142.7 million, in categories as follows: Rough or uncut, suitable for gem stones, not classified by weight, 1,025,183 carats valued at $88.9 million; cut but unset, not over 0.5 carat, 45,127 carats valued at $9.2 million; cut but unset, over 0.5 carat, 128,450 carats, valued at $44.6 million.

The 10 leading recipients of diamond exports accounted for 89% of the carats and 98% of the value and were as follows: Hong Kong, 98,102 carats valued at $132.5 million; the Netherlands, 39,033 carats valued at $39.7 million; Switzerland, 32,480 carats valued at $37.2 million; Japan, 46,924 carats valued at $33.5 million; Belgium, 25,827 carats valued at $25.8 million; France, 6,288 carats valued at $14.5 million; West Germany, 5,416 carats valued at $7.1 million; the United Kingdom, 4,671 carats valued at $4.7 million; Israel, 9,670 carats valued at $3.2 million; and Canada, 8,952 carats valued at $2.3 million.

The eight leading recipients of diamond reexports accounted for 96% of the carats and 97% of the value and were as follows: Belgium, 432,030 carats valued at $41.1 million; Israel, 403,017 carats valued at $34.3 million; the Netherlands, 213,537 carats valued at $25.2 million; the United Kingdom, 32,830 carats valued at $11.7 million; Switzerland, 7,832 carats valued at $8.9 million; France, 20,884 carats valued at $6.9 million; Japan, 26,764 carats valued at $5.6 million; and Hong Kong, 10,797 carats valued at $4.5 million.

Exports of all other gem materials amounted to $20.6 million. Of this total, pearls, natural and cultured, not set or strung, were valued at $0.6 million. Natural precious and semiprecious stones, unset, were valued at $18.0 million; and synthetic or reconstructed stones, unset, were valued at $2.0 million. Reexports of all other gem materials amounted to $12.8 million in categories as follows: Pearls, $0.8 million; natural precious and semiprecious stones, unset, $11.8 million; synthetic or reconstructed stones, unset, $0.1 million.

Imports of gem materials increased about 39% in value over those of 1975. Diamond accounted for 86% of the total value of gem material imports.

Although rough and uncut diamond imports were reported from 24 countries, over 99% of the value was from 9 countries as follows: The Republic of South Africa, 1,194,128 carats, $257.2 million; the United Kingdom, 494,884 carats, $113.8 million; Sierra Leone, 331,554 carats, $42.9 million; the Netherlands, 50,393 carats, $20.5 million; Israel, 38,573 carats, $8.2 million; Belgium-Luxembourg, 37,885 carats, $6.7 million; Venezuela, 260,066 carats, $6.0 million; Liberia, 2,790 carats, $2.9 million; and the Central African Republic, 36,006 carats, $2.2 million.

Cut but unset diamond, not over 1/2 carat, was imported from 38 countries; however, the imports of this category from 10 countries amounted to 99% of total carats and value as follows: Israel, 1,100,253 carats, $178.7 million; Belgium, 1,011,991 carats, $157.1 million; India, 498,996 carats, $64.7 million; the Netherlands, 68,419 carats, $9.6 million; the U.S.S.R., 35,794 carats, $8.1 million; the Republic of South Africa, 13,747 carats, $3.7 million; Switzerland, 12,673 carats, $1.7 million; the United Kingdom, 11,243 carats, $1.6 million; France, 9,276 carats, $1.9 million; and Hong Kong, 8,981 carats, $1.3 million. Cut but unset diamond, over 1/2 carat was imported from 30 countries; the imports from 9 countries amounted to 99% of the total carats and 98% of the value as follows: Belgium, 156,083 carats, $66.8 million; Israel, 102,563 carats, $32.5 million; the Republic of South Africa, 8,178 carats, $6.0 million; the Netherlands, 9,717 carats, $3.3 million; the U.S.S.R., 6,660 carats, $2.5 million; the United Kingdom, 2,661 carats, $2.0 million; Switzerland, 1,142 carats, $1.1 million; India, 3,389 carats, $0.8 million; and Hong Kong, 860 carats, $0.7 million.

Imports of emeralds increased 45% in quantity and 37% in value. Emerald was imported from 33 countries; the imports from 9 countries amounted to 96% of the carats and 94% of the value as follows: Colombia, 57,252 carats, $21.6 million; India, 578,780 carats, $9.7 million; Switzerland, 28,457 carats, $6.9 million; Brazil, 207,620 carats, $3.8 million; Israel, 76,805 carats, $2.7 million; the United Kingdom, 76,069 carats, $2.5 million; Hong Kong, 49,730 carats, $2.1 million; West Germany, 34,817 carats, $1.7 million; and France, 3,745 carats, $1.1 million. Ruby and sapphire were imported from 34 countries; the imports from 7 countries amounted to 91% of the value as follows: Thailand, $15.6 million; Sri Lanka, $2.3 million; India, $2.0 million; Switzerland, $2.0 million; Hong Kong, $1.8 million; West Germany, $0.7 million; and Canada, $0.4 million. Natural pearls and parts from 11 countries increased 12% in value of imports; 5 countries accounted for 91% of the value as follows: India, $371,000; Japan, $104,000; France, $85,000; Burma, $82,000; and Hong Kong, $48,000. Cultured pearls increased 52% in value of imports which were received from 20 countries of which Japan, at $10.6 million, accounted for 95% of the value. Imports of imitation pearls increased 32% in value; Japan, at $569,000, accounted for 84% of the value. Coral, cut but unset, and cameos suitable for use in jewelry increased slightly in value of imports, which were received from 20 countries; 3 countries accounted for 94% of the value as follows: Italy, $3.4 million; Taiwan, $1.5 million; and Japan, $1.2 million.

Imports of other precious and semiprecious stones, rough and uncut, increased 30% in value and came from 46 countries of which 7 countries accounted for 78% of the value as follows: Brazil, $2.5 million; Australia, $2.0 million; Colombia, $1.1 million; Hong Kong, $0.3 million; India, $0.2 million; the Republic of South Africa, $0.2 million; and Zambia, $0.2 million. Other precious and semiprecious stones, cut but unset increased 26% in value and were imported from 59 countries, of which 7 countries accounted for 87% of the value as follows: Hong Kong, $15.4 million; Brazil, $5.3 million; West Germany, $3.5 million; Australia, $2.9 million; Taiwan, $1.5 million; Iran, $1.0 million; and India, $1.0 million. Synthetic gem stones, cut but unset, increased 26% in value and came from 17 countries of which 6 countries accounted for 96% of the value as follows: West Germany, $5,639 million; France, $1,226 million; Switzerland, $1,191 million; Japan, $1,099 million; Taiwan, $0.272 million; and Hong Kong, $0.259 million. Imitation gem stones increased 9% in value and came from 18 countries, of which 5 countries accounted for 98% of the value as follows: Austria, $4,959 million; West Germany, $2,618 million; Czechoslovakia, $0.961 million; Japan, $0.252 million; and Hong Kong, $0.106 million.

Table 1.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stones	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Diamonds:				
Rough or uncut	2,341	347,882	2,464	462,657
Cut but unset	2,236	374,237	3,087	549,182
Emeralds: Cut but unset	806	40,348	1,165	55,286
Coral, cut but unset, and cameos suitable for use in jewelry	NA	6,475	NA	6,497
Rubies and sapphires: Cut but unset	NA	19,069	NA	27,165
Marcasites	NA	23	NA	20
Pearls:				
Natural	NA	673	NA	755
Cultured	NA	7,261	NA	11,062
Imitation	NA	515	NA	680
Other precious and semiprecious stones:				
Rough and uncut	NA	6,380	NA	8,266
Cut but unset	NA	28,718	NA	35,278
Other n.s.p.f	NA	1,935	NA	2,565
Synthetic:				
Cut but unset ... number	13,682	8,008	18,705	10,115
Other	NA	610	NA	766
Imitation gem stones	NA	8,296	NA	9,072
Total	NA	850,430	NA	1,179,366

NA Not available.

WORLD REVIEW

Australia.—Turquoise was discovered in Australia in 1967. The deposits are located in the remote central region of the Northern Territory approximately 265 miles northeast of the railhead at Alice Springs. The turquoise occurs in a series of Cambrian siltstone-mudstone beds that form part of the Sandover Beds of the Georgina Basin. A range of phosphate types is produced from the mine. Microscopic and X-ray diffusion examination have shown the typical high-grade material to be composed of very-fine-grained, close-packed nodules of turquoise. The turquoise has been formed by the chemical combination of phosphates and alumina in the phosphate-rich beds and copper leached from the overlying copper-rich tuffaceous siltstones. Mining is by open-cut methods. Specimens up to three-quarters ton have been recovered. Proven reserves are considerable, and continuity of supply is offered. A wide range of material is available for gem cutters and the carving trade. The area is not open to collectors and hobbyists.[6]

New markets for Australian opals are being opened both at home and in Japan. Stones from Cooper Pedy and Andamooka are being used in a variety of styles in watch bracelets and pendants. A new manufacturing process is reported to insure high durability of the stone.[7]

Botswana.—A new tax regime instituted by the Government of Botswana established an effective partnership between the Government and the De Beers Group. The Orapa mine produced 2,360,945 carats of diamond from 3,428,985 tons of ore in 1976. Construction work is in progress at Orapa to increase the capacity of the mine from 2.3 million carats to 4.5 million carats per year. The new Letlhakine mine, 24 miles southeast of Orapa was commissioned, and production began at the rate of 320,000 carats per year. The mine treated diamondiferous gravels surrounding the pipe. Design work was in progress for the second stage of development to treat the kimberlite. Prospecting continued at a kimberlite pipe discovered in Jwaneng in the south of the country. The pipe is overlain by 150 feet of overburden and represents a considerable technical achievement. A drilling program has established that the pipe is large and contains diamond in economic quantities.[8]

Burma.—The Mogok ruby that made Burma one of the gem capitals of the world has also been the cause of the country's plunder by smugglers and black marketeers. The gem industry was nationalized in 1969, and 18 kinds of precious stones including rubies, sapphires, and jade were brought under official control. Officials admit that thieves are still active despite strong security at the mines.[9]

[6]Cumming, J. Australian Turquoise. Lapidary J., v. 30, No. 7, October 1976, pp. 1634-1636.
[7]Mining Journal Conferences. New Uses for Opal. V. 287, No. 7375, Dec. 24, 1976, p. 510.
[8]De Beers Consolidated Mines Ltd. 1976 Annual Report, 59 pp.
[9]Maung, C. T. The Curse of the Burmese Ruby. Wash. Post, Apr. 18, 1976, p. H-3.

Table 2.—U.S. imports for consumption of diamond (exclusive of industrial diamond), by country

(Thousand carats and thousand dollars)

Country	1974				1975				1976			
	Rough or uncut		Cut but unset		Rough or uncut		Cut but unset		Rough or uncut		Cut but unset	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Angola	(1)	15	--	--	4	609	--	--	--	--	--	--
Belgium-Luxembourg	43	14,804	953	162,926	31	8,250	849	153,276	38	6,651	1,168	223,858
Bolivia	--	--	--	--	--	--	--	--	5	99	--	--
Brazil	1	535	4	642	5	982	3	491	1	79	4	690
Canada	(1)	(1)	(1)	52	--	--	1	156	(1)	6	(1)	90
Central African Republic	132	6,766	--	--	134	5,298	--	--	36	2,204	--	--
France	31	5,668	20	2,150	7	231	18	2,195	6	643	9	1,957
Germany, West	1	72	2	207	--	--	1	281	(1)	(1)	4	1,214
Hong Kong	(1)	65	5	772	--	--	5	847	1	825	10	1,962
India	--	--	221	26,709	--	--	300	37,211	--	--	502	65,432
Israel	37	8,052	774	128,856	33	5,523	902	147,114	39	8,239	1,203	211,146
Japan	1	77	4	854	1	77	2	428	1	51	6	1,001
Liberia	6	8,683	(1)	5	4	4,981	--	--	3	2,871	--	--
Netherlands	51	19,193	32	4,948	36	13,643	58	9,860	50	20,524	78	12,849
Portugal	1	408	(1)	1	5	570	2	473	--	--	--	--
Sierra Leone	453	57,577	1	82	272	32,696	(1)	83	331	42,861	1	129
South Africa, Republic of	389	68,948	23	9,786	927	189,885	21	7,777	1,194	257,249	22	9,674
Switzerland	2	251	8	1,587	(1)	42	4	1,087	1	29	14	2,796
U.S.S.R	--	--	15	3,609	--	--	43	9,215	--	--	43	10,607
United Kingdom	911	211,799	19	3,209	451	69,959	17	2,576	495	113,756	14	3,630
Venezuela	383	8,215	(1)	20	389	8,204	(1)	5	260	5,987	(1)	79
Western Africa, n.e.c	1	883	--	--	36	6,568	--	--	(1)	172	--	--
Zaire	2	200	(1)	18	3	152	--	--	--	--	--	--
Other	5	467	2	929	3	212	10	1,162	3	411	9	2,068
Total	2,450	412,678	2,083	347,362	2,341	347,882	2,236	374,237	2,464	462,657	3,087	549,182

[1] Less than 1/2 unit.

Significant quantities of Burmese jadeite ends up in Thailand through various smuggling routes. The price of fine apple and emerald green jadeite is such that a market has been created for the once-neglected yellow, red, and apricot colors. Much of the yellow and red material being offered is not jadeite but dyed quartz. The fraud may be detected by concoidal fractures on a chipped edge rather than the fibrous fracture displayed by jadeite.[10]

Colombia.—Two years ago small emeralds of little commercial value were discovered in alluvial sands near the small town of Yacopi. The discovery coincided with the closing of Muzo, the major emerald mine in Colombia. The increasing production from the Yacopi area gives evidence to the belief that soon something of real value will be discovered there. A major find at Yacopi would give Colombia a new source of foreign exchange.[11]

Guatemala.—Rough Maya jade will be made available to wholesale gem distributors and rockhounds. The jadeite is of excellent carving quality. The colors range from a pearly white and a richer green to a dark green that appears black when polished. The quality of the jade has been evaluated, and it compares favorably with Wyoming jade. Larger rough-cut boulders have been exported to Hong Kong for statue carving.[12]

Lesotho.—The Letseng-la-Terai mine began producing at a rate of 4,000 tons of ore per day. Systematic mining began in May with the object of exposing hard kimberlite at depth and stockpiling the overlying soft weathered kimberlite. At yearend, 500,000 tons of the weathered kimberlite had been stockpiled. The profitability of the mine depends on the production of a comparatively small quantity of large, high-quality stones.[13]

India.—The Indian diamond industry, which is export-oriented and cottage based, has grown twelvefold in the past decade and now provides employment to approximately 150,000 workers, mostly skilled artisans. The United States has emerged as one of the principal buyers of Indian diamond accounting for more than 27% of India's exports. India's share in the world diamond trade is about 7% to 8% in terms of value and 1.2% to 1.5% in terms of caratage. A combination of skills developed over the years and low production costs have enabled India to specialize in the polished small diamonds known as "makeables." The bulk of India's raw material requirments, namely, rough diamonds, is supplied by the Diamond Trading Company (DTC), London. The outlook for the industry is encouraging.[14]

Iran.—Iranian production of turquoise from March 21, 1975 to March 20, 1976, was reported as 68.2 short tons. Proven reserves were reported as 11,000 short tons and resources as 22,000 short tons.[15]

Pakistan.—The Government of Pakistan decided to set up an organization to buy uncut emeralds, diamonds, and other precious stones from the mines at Swat in the North West Frontier Province and export them in finished form. The mines have been sealed by the police and mining operations suspended for the present. Of the 800 carats of emerald produced per month, a large proportion was said to be smuggled out of the country.[16]

South Africa, Republic of.—The Central Selling Organization reported diamond sales in 1976 of $1,555 million, 46% greater than in 1975. During 1976, sales exceeded production, and the excess was provided from stocks. The Central Selling Organization increased the price of diamond twice in 1976, by 3% in January and 6% in September. The demand for the smaller sizes and the lower qualities of larger diamonds was very strong in 1976. Toward the end of the year, there was improvement in demand for better quality large stones. No breakdown of gem stones or industrial diamond sales was given.[17]

South-West Africa, Territory of.—The Consolidated Diamond Mines of South-West Africa (Proprietary) Ltd. reported an increase in ore treated in 1976 to 14,167,067 short tons, from 13,498,048 tons in 1975. The average stone size increased from 0.73 carat per stone to 0.95 carat per stone in 1976. Overburden stripped increased from 46,389,670 short tons in 1975 to 54,996,027 tons in 1976. Diamond production decreased to 1,693,994 carats in 1976 from 1,747,739 carats in 1975.

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[10] Greenspan, J. The Latest Ripoff: Yellow-Red Burma Jade. Lapidary J., v. 29, No. 11, February 1976, p. 2084.

[11] World Mining. Colombian Miners Seek Emeralds at Yacopi as Famed Muzo Mine Closed. V. 29, No. 4, April 1976, pp. 88-89.

[12] Swezey, W. R. Ancient Maya Jade Deposits Rediscovered. Lapidary J., v. 30, No. 3, pp. 742-746.

[13] De Beers Consolidated Mines Ltd. 1976 Annual Report, 59 pp.

[14] U.S. Embassy, New Delhi, India. State Department Airgram A-87, Dec. 23, 1976, 8 pp.

[15] U.S. Embassy, Tehran, Iran. State Department Airgram A-225, Dec. 29, 1976, Enclosure 1: 1 pp.

[16] Mining Journal. Production Smuggling in Swat. V. 286, No. 7337, Mar. 5, 1976, p. 183.

[17] De Beers Consolidated Mines Ltd. 1976 Annual Report, 59 pp.

Further refinements made to the dewatering systems and stability improvements to the sea wall enabled operations to advance 150 feet further seaward of the high water mark. Fewer minor breakdowns were experienced with the bucketwheel excavator during the year, but three major component failures decreased overall availability.

Thailand.—Many of Thailand's precious and semiprecious stone mines are nearing depletion, resulting in a marked increase in importation of blue sapphires from Australia. Smuggling of gem stones from Burma and Cambodia also increased.[18]

U.S.S.R.—Soviet geologists are reported to have made diamond finds in ancient Timan paleozoic deposits west of the Urals.[19]

The Frankfurt diamond bourse has gone into receivership. German promoters attempted to make Frankfurt a world diamond market using cutters from Idar-Oberstein to challenge the dominance of Israel, Antwerp, New York, and Bombay. Breaking into a trade that is divided between De Beers and the many Israeli and Belgian craftsmen was too big a task for the Germans even with Soviet help.

It is reported that the U.S.S.R. has opened an export office in Antwerp under the name of RUSSALMAZ MV. It is also reported that the U.S.S.R. is selling the bulk of its finished goods to the Diamond Trading Co. marketing network since attempts to compete directly had failed.[20]

[18]U.S. Embassy, Bangkok, Thailand. State Department Airgram A-140, June 16, 1976, 8 pp.
[19]Mining Journal. Industry in Action: Exploration. V. 287, No. 7352, July 16, 1976, p. 51.
[20]McInnes, N. A Soviet Investment. Barron's, v. 56, No. 1, Jan. 5, 1976, p. 4.

Table 3.—Diamond (natural): World production, by country[1]

(Thousand carats)

Country	1974			1975			1976[p]		
	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total
Africa:									
Angola	1,470	490	1,960	345	115	[e]460	495	165	[e]660
Botswana	408	2,310	2,718	360	2,037	2,397	354	2,007	2,361
Central African Republic	220	118	338	220	119	339	221	119	[e]340
Ghana	257	2,315	2,572	233	2,095	2,328	228	2,055	2,283
Guinea[e]	25	55	80	25	55	80	25	55	80
Ivory Coast	112	167	279	84	125	209	22	38	60
Lesotho[2]	2	9	11	1	2	3	1	2	[e]3
Liberia[3]	377	259	636	[4]241	[4]165	[4]406	250	150	[e]400
Sierra Leone[e]	670	1,000	1,670	600	900	1,500	600	900	1,500
South Africa, Republic of:									
Premier mine	605	1,817	2,422	509	1,527	2,036	458	1,375	1,833
Other De Beers properties[5]	2,397	1,961	4,358	2,518	2,061	4,579	2,549	2,086	4,635
Other	438	292	730	408	272	680	332	222	554
Total	3,440	4,070	7,510	3,435	3,860	7,295	3,339	3,683	7,022
South-West Africa, Territory of	1,491	79	1,570	1,660	87	1,747	1,609	85	1,694
Tanzania	249	249	498	224	224	448	225	225	[e]450
Zaire	[r]620	[r]12,991	13,611	395	12,415	12,810	591	11,230	11,821
Other areas:									
Brazil	127	127	254	135	135	[e]270	135	135	[e]270
Guyana	12	18	30	8	13	21	6	8	14
India	18	3	21	17	3	20	17	3	20
Indonesia[e]	12	3	15	12	3	15	12	3	15
U.S.S.R	1,900	7,600	9,500	1,950	7,750	9,700	2,000	7,900	9,900
Venezuela	279	970	1,249	239	821	1,060	190	643	833
World total	[r]11,689	[r]32,833	44,522	10,184	30,924	41,108	10,320	29,406	39,726

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Total (gem plus industrial) diamond output for each country is actually reported except where indicated to be an estimate by footnote. In contrast, the detailed separate reporting of gem diamond and industrial diamond represents Bureau of Mines estimates in the case of every country except Lesotho (1974-75), Liberia (1974), Venezuela (all years), and Zaire (1974-75) where sources give both total output and detail. The estimated distribution of total output between gem and industrial diamond is conjectural in the case of a number of countries, based on unofficial information of varying reliability.
[2]Exports of diamond originating in Lesotho; excludes stone imported for cutting and subsequently reexported.
[3]Exports.
[4]Partial figure; January 1 through December 15 only.
[5]All company output from the Republic of South Africa except for that credited to the Premier mine; also excludes company output from the Territory of South-West Africa and Botswana.

TECHNOLOGY

Ruby crystals were subjected to a static pressure greater than 1 megabar in a diamond-windowed pressure cell. The pressure was monitored continuously by observing the spectral shift of the sharp fluorescent Ri ruby line excited with a calcium-helium gas-diffusion laser beam. One megabar appears to be the highest pressure ever reported for a static experiment in which an interval calibration was employed. The accessibility of this pressure range, coupled with the high temperature already reached, makes it possible to experiment directly at the conditions of the earth's core.[21]

General Electric (GE) scientists successfully tested a new machine that can apply pressures greater than 8 million pounds per square inch. To achieve and maintain these pressures, GE created a pair of tungsten carbide pistons tipped with the company's manufactured industrial diamonds. The apparatus will be used to study changes that occur in materials under high pressures and temperatures.[22]

Two distinct suites of minerals included in natural diamond are described. It is indicated that they probably represent different physical and chemical conditions during diamond growth. Detailed mineralogical and chemical study of the minerals included in diamond during its growth can provide significant data regarding the chemistry and physics of the upper mantle, as well as providing insight into the genesis of diamond.[23]

A detailed analysis of the composition of gaseous inclusions in seven Arkansas diamonds ranging in size from 0.37 to 2.06 carats and containing other inclusions was made by mass spectrographic techniques. The released gases were found to be of variable compositon and similar to those reported earlier from diamonds of African origin. Based on the tentative assumption that the gases are genetically related to the host diamond, a theoretical gas-solid diamond growth model was presented, which can account for the observed compositional variations in the included gases.[24]

There are three significant features in the typical appearance of opal that provide clues to the mechanism responsible for the color display: (1) The color is associated with small grains, and throughout each grain the color is fairly uniform, (2) the color of the grains changes as the orientation of the stone is changed with respect to the light source and the observer, and (3) generally the colors are spectrally pure. Electron micrographs revealed regular geometric patterns of tiny holes across the entire surface of a grain. These arrays of holes are sufficiently regular to act as three-dimensional diffraction gratings that give rise to the stones' characteristic fire.[25]

The Spencer mines in Idaho produced gem opal, which not only has the intense color of Australian doublets and triplets, but has an additional feature of displaying a star of brilliant colors. There are three types of stars to be found among the Idaho gems: A cat's eye stone that exhibits a single streak of dispersed colors across the triplet, a three-ray star, and a six-ray star. Stars such as these have not been reported for Australian opal.[26]

Two major techniques, flux and hydrothermal, have been used to grow emerald crystals, and various solvents have been employed. The lithium molybdate flux has proved to be commercially viable in the hands of Chatham and Gilson. Hydrothermal work, using two acid mineralizers, which gave satisfactory growth, did not prove to be commercially viable.[27]

Color changes were observed on gamma-ray irradiation of over 500 colorless, pink, blue, and green tourmalines. The only significant changes observed were the development or intensification of pink or the development of yellow superimposed on the preexisting color. Some of these colors are stable to heat, and some are not.[28]

The well-known brown color produced by the irradiation of topaz has been reexamined particularly with respect to the kinetics

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[21]Mao, H. K. and P. M. Bell. High Pressure Physics: The 1-Megabar Mark on the Ruby Ri Static Pressure Scale. Science, v. 191, No. 4229, Feb. 27, 1976, pp. 851-852.

[22]American Metal Market/Metalworking News. GE Machine Able to Generate 8 Million Pounds of Pressure. V. 83, No. 111, June 7, 1976, p. 27.

[23]Meyer, H. O. A. and H. M. Tsai. Mineral Inclusions in Diamond: Temperature and Pressure of Equilibrium. Science, v. 191, No. 4229, Feb. 27, 1976, pp. 849-851.

[24]American Mineralogist. Experimental Results and a Theoretical Interpretation of Gaseous Inclusions Found in Arkansas Natural Diamonds. V. 60, No. 5-6, May-June, 1975, pp. 413-418.

[25]Darragh, P. J., A. J. Gaskin, and J. V. Sanders. Opal. Sci. Am., v. 234, No. 4, April 1976, pp. 84-85, 88-95.

[26]Sanders, J. V. Star Opal From Idaho. Lapidary J. v. 29, No. 11, February 1976, pp. 1986, 1988, 1990, 1992, 2008, 2010.

Nassau, K. Synthetic Emerald: The Confusing History and the Current Technologies. Part I, Lapidary J., v. 30, No. 1, April 1976, pp. 196-202.

[27]Nassau, K. Synthetic Emerald: The Confusing History and the Current Technologies. Part II. Lapidary J., v. 30, No. 2, May 1976, pp. 468, 470, 472, 488, 490, 492.

[28]Nassau, K. Gamma Ray Irradiation Induced Changes in the Color of Tourmalines. Am. Mineralogist, v. 60, No. 7-8, July-August 1976, pp. 710-713.

of the color formation. The known color is produced at two different rates. Heating to 200 for a few hours removes essentially all the color of the specimens tested.[29]

A completely new comparison microscope assists the geologist and mineralogist in the accurate identification of minerals by color. The Lovibond-Nelson microcolorimeter is based on an optically linked pair of microscopes using a single light source. Accurately graded glass filters are calibrated to the Lovibond subtractive color system and give an optical match with a sample.[30]

An automatic cutting machine, The Piermatic, an English invention, cuts small diamond stones with efficiency and consistency of make. Machines are in use in Israel, New York, and Puerto Rico. Use of the machine is usually limited to stones of about 30 points.[31]

Modern technology in the form of aerial photographs offers major assistance to mineral collectors. Photograph prints available from film libraries show settlers' homesteads, derelict railways, ghost towns, or any kind of habitation or clearing. Fifty-year-old bush trails show plainly no matter how overgrown they have become. Careful study of photographs will often save many miles of wandering in search of prospective sites.[32]

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[29]Nassau, K. and B. E. Prescott. Blue and Brown Topaz Produced by Gamma Irradiation. Am. Mineralogist, v. 60, No. 7-8, July-August 1976 pp. 705-709.

[30]Mining Journal. Methods and Machines. Microcolorimeter for Mineral Identification. V. 286, No. 7342, May 7, 1976, p. 363.

[31]Jeweler's Circular-Keystone. Gemstones. Automatic Diamond Cutting in N.Y. V. 146, No. 7, June 1976, p. 46.

[32]Hutchinson, W. and J. Hutchinson. Genuine Treasure Maps. Lapidary J., v. 30, No. 3, June 1976, pp. 818-821.

Gold

By John M. West[1] and W. C. Butterman[2]

A 22% drop in the price of gold discouraged producers and favored consumers in 1976. International Monetary Fund (IMF) sales, totaling 3.9 million ounces, had a major impact on prices, which reached a low in August after the second sale had taken place. Thereafter, prices tended to recover despite additional sales. Another factor in prices was the accelerated sale of gold to U.S. markets from stocks of foreign-owned metal on deposit at the Federal Reserve Bank in New York City which amounted to 2.13 million ounces in 1976 versus 0.58 million ounces in 1975. During the year, an increasing quantity of unaccountable gold apparently was accumulated in private stocks being held for speculative and investment purposes. Reported stocks of industry and trading firms increased 0.14 million ounces. Exports (nonmonetary) exceeded imports in 1976 by 0.22 million ounces, up from 0.03 million ounces excess in 1975. Consumption was 0.66 million ounces higher than in 1975.

Refined production from domestic primary and secondary sources declined 13% and 7% respectively. Mine production was down slightly, mostly because of the closing of the Cortez mine in Nevada. Heap leaching of gold, a recently developed technology, provided 3% of U.S. production, slightly less than in 1975. Because of price drops, some producers chose to hold gold in unrefined form in anticipation of higher prices. Similarly, the supply of gold to scrap processors was somewhat less because refining and turnaround time was a less significant factor with dropping prices, and scrap was held for improved markets.

Futures trading in gold was active, mainly in the New York and Chicago markets, with volume about 15% higher than in 1975. In New York, Commodity Exchange Inc. (COMEX) had a trading volume of 48 million ounces compared with 36 million in 1975; in Chicago, the International Monetary Market (IMM) reported a volume of 34 million ounces compared with 36 million ounces in 1975. Monthly volume of the COMEX ranged between 1.9 million ounces in April and 8.75 million ounces in December. An exceptional jump was noted from October, when volume was 2.90 million ounces, to November, when volume was 8.51 million ounces. December 13 was a record day for trading when 1.08 million ounces changed hands. On the IMM, monthly volume ranged from 1.83 million ounces in April to 4.74 million ounces in November, while December volume declined to 3.88 million ounces. Gold moved into and was delivered from the exchanges and the net stocks declined about 0.2 million ounces during the year.

IMF gold sales began in midyear for the purpose of providing capital for low interest loans to developing countries. Dates of sales were as follows: June 2, July 14, September 15, October 27, and December 8. Each sale amounted to 780,000 ounces, except for the October sale, which was 779,200 ounces. The gold was delivered at the Federal Reserve Bank in New York, except for that from the December sale, which was delivered in London. Sales in June, July, and December were by the common lowest-accepted-price Dutch auction method; the others were by the bid price method. Prices were $126, $122.05, and $137 per ounce in the June, July, and December sales, and averaged $109.40 and $117.71 in the September and October sales. The IMF planned to sell a total of one-sixth of its stocks, or 25 million ounces, over a 4-year period, and planned to restore an equal portion to member countries. Restitution was scheduled to begin in January 1977, and it was uncertain whether central banks receiving such gold would place it on the market immediately or hold it for the longer term.

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The Bank for International Settlements (BIS) estimated an increase in 1976 of world gold supplies by 25% to 45.2 million ounces from all sources, including primary production of 30.4 million ounces, net sales from centrally planned economies of 11.3 million ounces (up 75% from 1975), and 3.5 million ounces from official gold stocks. Gold reserves of the South African Reserve Bank declined 5.14 million ounces, mainly because of an agreement between a group of commercial banks and the Reserve Bank to swap gold, which was similar in effect to a futures trade; however, this had no impact on overall stock balances. The BIS reported that fears of revived inflationary pressures and disappointment with performance of equity markets probably contributed to an increased investment demand for gold.

World consumption was up 29%, according to Consolidated Gold Fields Ltd., largely stimulated by an increased demand for jewelry and investment items, such as small bars for delivery in the Middle East and the Far East. Fabrication in karat jewelry rose 83%. Sales of South African krugerrand gold coins containing 1 troy ounce per coin declined to 3.0 million ounces content compared with 4.7 million ounces in 1975. To expand sales, International Gold Corp., the krugerrand marketing agency, launched a major advertising campaign. Private bullion purchases, excluding coins, were estimated to have dropped sharply to 2.9 million ounces from 5.3 million ounces in 1975. U.S. Treasury stocks of gold were lower at yearend owing to use of gold in Bicentennial medals, which were sold by the American Revolution Bicentennial Administration and manufactured by the Bureau of the Mint. Gold content of the medals sold was 22,756 ounces, and sales, which were by subscription, totaled $6.8 million. The Royal Canadian Mint issued two gold coins in commemoration of the Olympic Games consuming about 0.34 million ounces of fine gold in 1 million coins.

Table 1.—Salient gold statistics

	1972	1973	1974	1975	1976
United States:					
Mine production thousand troy ounces	1,450	1,176	1,127	1,052	1,048
Value thousands	$84,967	$115,000	$180,009	$169,928	$131,340
Ore (dry and siliceous) produced:					
Gold ore thousand short tons	3,316	4,715	4,598	5,722	3,063
Gold-silver ore do	173	124	65	137	1,027
Silver ore do	355	370	560	r672	651
Percentage derived from:					
Dry and siliceous ores	58	52	58	62	61
Base-metal ores	41	47	41	36	36
Placers	1	1	1	2	3
Refinery production:[1]					
From domestic ores thousand troy ounces	1,478	1,210	1,021	1,093	954
Secondary do	2,107	1,779	1,926	2,696	2,504
Exports:[2]					
Commercial do	766	601	570	2,689	2,879
Government do	706	2,384	3,293	807	652
Total do	1,472	2,985	3,863	3,496	3,531
Imports, general[2] do	6,126	3,845	2,651	2,662	2,656
Gold contained in imported coins do	--	--	3,090	1,673	1,333
Sales from foreign stocks in Federal Reserve Bank do	--	1,704	2,144	577	2,125
Stocks, Dec. 31:					
Monetary[3] millions	$10,487	$11,652	$11,652	$11,599	$11,598
Industrial[4] thousand troy ounces	4,407	4,498	5,670	788	928
Consumption in industry and the arts do	7,285	6,729	4,651	3,993	4,648
Price:[5] Average per troy ounce	$58.60	$97.81	$159.74	$161.49	$125.32
World:					
Production thousand troy ounces	44,843	43,297	r40,124	r38,676	39,322
Official reserves[6] millions	r$44,747	r$49,664	r$49,614	r$49,550	$49,188

rRevised.
[1]From domestic ores—U.S. Department of the Treasury, 1972-74, and Bureau of Mines, 1975 and 1976.
[2]Excludes coins.
[3]Gold valued at $38 per troy ounce in 1972, and $42.22 per ounce 1973-76. Includes gold in Exchange Stabilization Fund.
[4]Gold content of all products in stocks held by manufacturers, and refiners, 1972-74; gold content of bullion only in 1975 and 1976 (excludes trading stocks). Stocks at beginning of 1975 amounted to 1,896,000 ounces of bullion.
[5]Engelhard Industries quotations.
[6]Held by market economy central banks and governments; gold valued at $38 per troy ounce in 1972, and $42.22 per ounce in 1973-76.

Legislation and Government Programs.—Public Law 94-450, The Gold Labeling Act of 1976, which amended the Act of June 13, 1906, and reduced permissible deviation in gold content of articles made in whole or part of gold, was signed October 1, 1976. The tolerance was reduced from 1/2 of 1 karat to 3 parts per thousand for most articles, or if soldered, to 7 parts per thousand. The Act was to take effect 5 years after the date of enactment and was not to apply with respect to any article of merchandise sold by any manufacturer or importer before the effective date of October 1, 1981. The purpose of the act was to assist the domestic industry to meet the requirements of foreign countries, thereby increasing U.S. exports. A major U.S. supplier to the jewelry industry announced it would entirely remove tolerances from its gold products as of January 1, 1977.

The U.S. Customs Service issued a statement repealing parts of the Gold Reserve Act of 1934 in conformance with current public laws.[3] The section repealed applied to a provision that importation and exportation were governed by laws administered by the Department of the Treasury. Public laws that went into effect December 31, 1974, say that no provision of any law, and no rule, regulation, or order in effect on that date may be construed to prohibit any person from purchasing, holding, selling, or otherwise dealing with gold in the United States or abroad.

The Commodity Futures Trading Commission voted to permit continued trading of leverage contracts in gold and silver bullion and coins while it drafted more stringent regulations on such trading. The Commission released a study of leverage transactions and proposed a number of restrictions it might impose in accordance with its authority which is specified in the Commodity Futures Trading Act of 1974. Several proposals to establish gold bullion options trading markets were delayed pending actions by the Commission.

DOMESTIC PRODUCTION

Closure of the Cortez mine in Nevada resulted in a 13% drop in Nevada production; however, increases in output from the Homestake mine in South Dakota, a placer operation at Nome, Alaska, and copper mines in Arizona and Montana offset most of the drop, and U.S. production was only slightly below that of 1975. Byproduct production supplied 36% of all primary gold output, the same as in 1975, and most of this was from copper ores mainly mined by open pit methods. Placer gold production rose from 2% to 3% of the total output in 1976 as a result of increased dredging at Nome. Alaskan sources provided 82% of the placer total.

Five leading producers accounted for 68% of U.S. production. These were Homestake Mining Co., Carlin Gold Mining Co., Kennecott Copper Corp., Standard Metals Corp., and Duval Corp. Operations in the list of 25 leading mines (table 5) supplied 95% of all production, and a large number of mines provided the remaining 5% which amounted to 55,752 ounces. Lode mines reporting gold as a principal product totaled 74, and as a byproduct, 100. Placer mines totaled 49, the same as in 1975. California and Colorado placer production included gold recovered at sand and gravel producing plants. Cyanidation was used in recovering 56% of all gold, and mercury amalgamation, 2%; 40% of all gold came from 5.9 million tons of smelted concentrates. Mills treated 290.6 million tons of ore, but most of this was copper ore in which gold was a minor constituent.

Gold refiners reported production of 3.58 million ounces of refined bullion, 11% less than in 1975 (table 10). Domestic ores and concentrates supplied 27% of the total refined, and 3% was contained in imported ores and concentrates. Scrap provided the remainder with the contribution from new scrap exceeding that from the old scrap. The total amount reported from scrap was 7% lower than in 1975.

[3]Federal Register. Rules and Regulations, Title 19 - Customs Duties, Chap. 1, U. S. Customs Service, Department of the Treasury. V. 41, No. 11, Jan. 16, 1976, p. 2383.

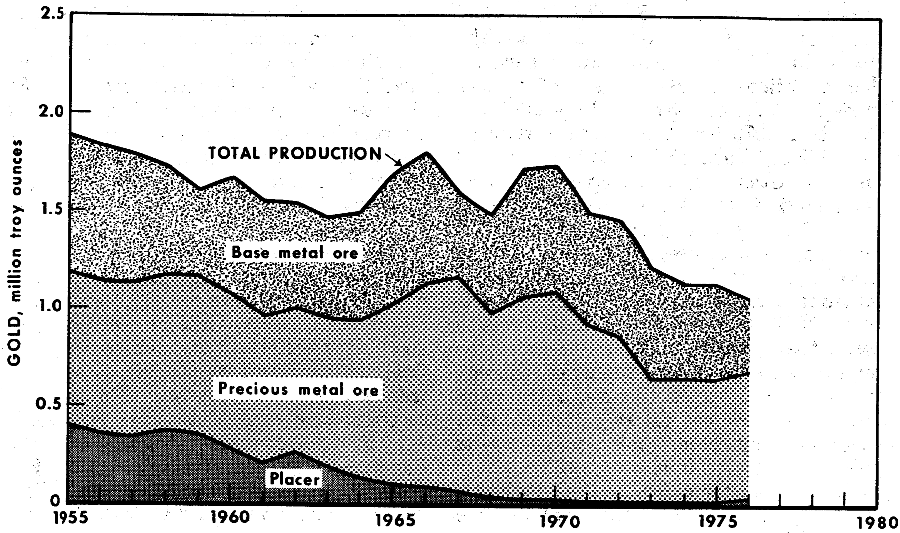

Figure 1.—Sources of U.S. gold production.

The ASARCO, Inc. Perth Amboy, N. J., refinery was closed in March 1976 and remaining gold refining operations were transferred to the company's new Amarillo, Tex., plant. AMAX Inc. produced 716,450 ounces of refined bullion at its Carteret, N. J., refinery in 1976, 15% less than in 1975. Homestake Mining Co. refined all its own production, which was up 4% in 1976, and refined some purchased or tolled material at its Lead, S. Dak., refinery. A number of secondary refiners were active in scrap processing.

Homestake Mining Co. reported an operating loss of $1.5 million in 1976 compared with $13.9 million operating earnings in 1975. In 1976, gold bullion sales were valued at $39.8 million from its Lead, S. Dak., mine. The average price realized from gold sales was $124.71 per ounce compared with $163.58 in 1975. Production was reported at 318,487 ounces from 1.66 million tons of ore, with an average recovery grade of 0.192 ounce per ton, slightly less than the 0.207 ounce figure in 1975. Gold recovery was 95.1%. Mine production came mainly from cut and fill stopes on the 7, 9, 11, 13, 19, and 21 ledges above the 6,800 level. Several shrinkage stopes and a blast hole stope located on the 2,300 level also contributed. The company completed 74,000 feet of underground exploration drilling above the 6,800 level and found additional ore in the 12 and 19 to 21 ledge areas. Ore reserves totaled 14.3 million tons averaging 0.229 ounce per ton at yearend 1976 versus 15.3 million tons averaging 0.264 ounce per ton in 1975. Construction of a new tailings dam and pumping system for pollution control was 80% complete at yearend. A 3-year labor agreement was signed in mid-1976.

The Carlin Gold Mining Co., owned by Newmont Mining Corp., reported production of 208,000 ounces of gold from 861,000 tons of ore milled in 1976; the grade averaged 0.272 ounce per ton. Production was down 2% from that in 1975, and grade was down from 0.292 ounce per ton. The tonnage of ore and waste mined more than doubled to 12.6 million tons because of modifications to open pit designs in reaching for deep ore under the main Carlin Pit. Production was mostly from the Carlin mine but included 136,731 tons averaging 0.093 ounce per ton from the Blue Star mine and 129,700 tons from the Bootstrap mine. Sales were valued at $25.9 million in 1976, 22% lower than in 1975. Ore reserves at the end of 1976, excluding 700,000 tons of high carbon material still under evaluation, totaled 5.27 million tons averaging 0.208 ounce per ton compared with 5.0 million tons averaging 0.221 ounce per ton at the end of 1975. Also, 0.8 million tons of 0.025 ounce per ton material was stockpiled from the Blue Star and Bootstrap mines for possible future extraction. A new double-oxidation cyanide process was developed for treating refractory carbonaceous ores, and additional chlorine leaching equipment was installed.

Cortez Gold Mines closed its Cortez mill in August 1976 after exhausting ore reserves at the Cortez and Gold Acres mines.

Only 9,000 ounces of gold was produced by milling, but an additional 18,700 ounces was produced by heap leaching. This compared with 48,500 ounces by milling and 25,400 ounces by leaching in 1975. Recovery of milled gold was down slightly to 77% and grade averaged 0.084 ounce per ton. Mining equipment was sold in September and most of the mill was "mothballed" pending further exploration.

At Republic, Wash., Day Mines, Inc. negotiated to acquire the Knob Hill Mines, Inc. property and facilities and planned further exploration. Day Mines produced 3,379 tons of ore averaging 0.643 ounce of gold per ton and 1.62 ounce of silver per ton from its Gold Dollar Lease, and its share of the No. 3 joint operation with Knob Hill was 6,890 tons averaging 0.441 ounce of gold per ton and 2.27 ounce of silver per ton.

Alaska Gold Co., owned by UV Industries, Inc., operated its No. 5 bucketline dredge at Nome and reequipped a second dredge located near the Nome airport. The company's smaller bucketline dredge at Hogatza in the Fairbanks area was idle. Northgate Exploration Ltd. and Westfield Minerals Ltd. drilled from ice flows to test offshore gold placer possibilities near the mouth of Daniels Creek, Alaska. ASARCO held leases to offshore gold deposits near Nome, Alaska, awaiting higher gold prices.

Bucketline dredging at the Yuba Goldfields Inc. property, Hammonton, Calif., was suspended in early 1976 because of inadequate returns. The unit had produced 5,600 ounces since startup in May 1975. Earth Resources Co. expected to begin silver-gold cyanide leaching at Delamar, Idaho, in early 1977. The property was scheduled to produce 15,000 ounces of gold annually, treating 1,700 tons of ore per day. Placer Amex Inc. terminated an agreement with Nevex Mines to explore and develop Nevex's Thunder Mountain, Idaho, gold properties. Ores generally containing 0.1 ounce of gold per ton were found during the project. Kennecott Copper Corp. shipped dump material and did development work on its Mammoth gold mine in the Tintic district of Utah. Smoky Valley Mining Co. rescheduled startup of a major heap leach gold facility at Round Mountain, Nev., delaying initial production until 1977. Standard Slag Co.'s new Atlanta mine in Nevada produced at capacity during 1976.

CONSUMPTION AND USES

U.S. consumption of gold in industry and arts, based on conversion of bullion into primary products, totaled 4.65 million ounces in 1976, 16% higher than in 1975. Consumption by end use was as follows, in thousand ounces (with 1975 figures in parentheses): Jewelry and arts, 2,562 (2,080); dental, 694 (595); industrial, 1,233 (1,059); and investment products, 159 (258). Jewelry and arts accounted for 55% of consumption; dental, 15%; industrial, 27%; and investment products, 3%. An estimated 66% of all gold went into products containing over 40% gold by weight (karat golds, dental alloys, investment products), the same as in 1975; 15% was used in electroplated products, and the rest went into rolled, gold-filled, and other forms of products. U.S. consumers also purchased gold in the form of imported gold coins, generally 900 fine or better, amounting to 1.33 million ounces content, 20% less than in 1975.

Generally, less effort was reported in reducing use of gold in 1976 owing to price declines, although research and application of more efficient fabrication techniques continued at a high level. Jewelers reported sales increases in 14-karat and gold-filled products surpassing those in more expensive items. Two-tone gold was said to be increasingly popular. Scrap refiners indicated reduced values of gold in electronic scrap and increased silver owing to more widespread silver-plating as a substitute for gold. Gold was reported to be "holding its own" in the electronic connector industry—despite efforts at substitution—owing to its outstanding properties in connecting such items as circuit boards.[4] Goldless tin alloy connectors were reported to have made market inroads, but the trend may have been reversed.[5] Selective and thinner plating and the use of smaller plated dots for contact points led to more efficient use of gold by many firms. The thick fiber process

[4] Wind, W. J. Connector Maker Backs Gold. Am. Met. Market, v. 82, No. 221, Nov. 12, 1976, p. 19.

[5] Larson, R. Substitutes Frustrate Electronics Firms. Am. Met. Market, v. 82, No. 221, Nov. 12, 1976, p. 17.

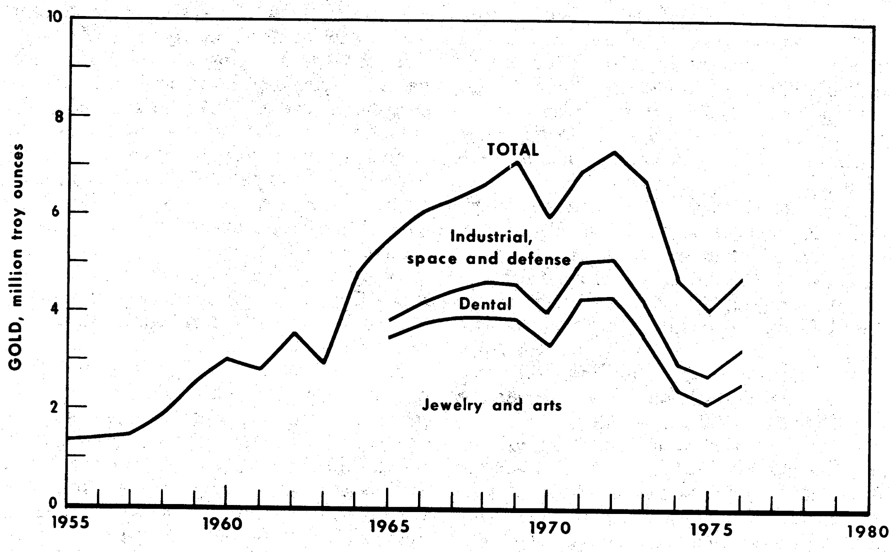

Figure 2.—Gold consumption in the United States.

of applying gold to various kinds of electronic parts was described, and the possible eventual substitution of thick-fiber copper pastes was suggested.[6] Palladium-gold conductors were compared with pure gold conductors for performance characteristics. Inlay-clad gold was used increasingly as an alternative to electrodeposited gold in electronics, with particular interest shown by telephone equipment manufacturers. An excellent description of the properties of inlay-clad products was published.[7] A growing and significant portion of dental alloys was being converted to nongold products or alloys of lower gold content. A large manufacturer expanded its line of full karat gold solders to assist users in complying with requirements of the New Gold Act requiring jewelry manufacturers to meet more exacting standards in 1981.[8]

STOCKS

Monetary.—U.S. Treasury gold stocks were valued at $11,598 million at yearend 1976, $1 million lower than at yearend 1975, and amounted to 274.70 million ounces. Monetary gold stocks remained officially valued at $42.22 per troy ounce, but no gold was bought or sold at that price. Earmarked gold held in Federal Reserve Banks for foreign official accounts amounted to 388.77 million ounces, down 7.84 million ounces from yearend 1975. Gold went to both domestic and export markets. Movements out of the Federal Reserve Bank included 3.9 million ounces sold and delivered from IMF stocks. The Federal Reserve Bank discontinued its series of statistics on world monetary stocks of gold.

The IMF reported world gold reserves in the IMF and central banks, exclusive of centrally planned economies, at yearend 1976 as 40,788 million Special Drawing Rights (SDR's) (35 SDR's equivalent to 1 ounce of gold). IMF holdings amounted to 5,233 million SDR's. Industrial countries held 84% of the gold of all countries. Gold held by the IMF declined 3% during 1976 as a result of the gold sales.

Industrial and Trading Stocks.—Industrial stocks of 995 fine or better gold held by refiners, fabricators, and dealers at yearend totaled 928,000 ounces, 18% higher than at yearend 1975. Trading stocks, held mainly by COMEX and IMM, totaled an estimated 0.3 million ounces compared with 0.5 million ounces at yearend 1975. Yearend 1976 stocks registered and eligible for trad-

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[6]Caley, R. H. Gold in Thick-Film Conductors. Gold Bull., v. 9, No. 3, July 1976, pp. 70-75.

[7]Russell, R. J. Inlay-Clad Gold Alloys. Gold Bull., v. 9, No. 1, January 1976, pp. 2-6.

[8]American Metal Market. H & H Broadening Line of Full-Karat Gold Solder. V. 84, No. 67, Apr. 6, 1977, p. 8.

ing by COMEX were 292,099 ounces; those in the IMM totaled 317,986 ounces (includes most of COMEX stocks also); the Chicago Board of Trade held 15,914 ounces.

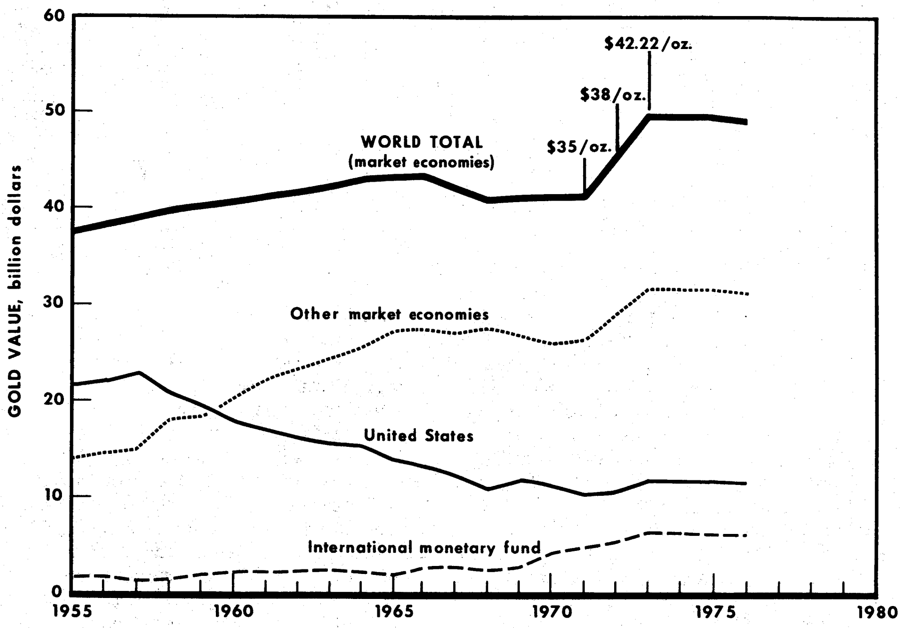

Figure 3.—World monetary gold stocks.

PRICES

Prices for unfabricated gold, quoted daily by Engelhard Industries, began the year at $140.85, the high for the year, and declined to a low of $103.50 on August 30. Thereafter, daily prices rose ending the year at $135.25. Except in March, monthly prices declined until August, thereafter they rose and were the highest for the year at $134.38 in December. Monthly prices showed the greatest stability from February through June when monthly ranges from high to low were less than $6. In July, after the IMF began selling gold, the range jumped to $15.55. In November the range reached $16.25, then dropped to $7.15 in December. The average price for the year was $125.32 compared with $161.49 in 1975. London final prices generally were 50 cents lower than Engelhard Industries prices and averaged $124.84 in 1976. Most central banks continued to value gold at an official price of $42.22 per ounce but made no sales or exchanges at that price. The IMF had a different official price, based on changes in value of a "basket" of currencies of major trading countries, and IMF gold was valued at 35 SDR's per ounce, which was equivalent to $40.66 per ounce at the arithmetical average of $1.16183 per SDR for 1976.

FOREIGN TRADE

Domestic exports of gold totaled 3.53 million ounces valued at $375.0 million in 1976, and of these exports, 0.65 million ounces valued at $27.5 million was monetary gold. This gold went to Switzerland (0.62 million ounces) and Poland (0.03 million ounces). Exports of nonmonetary refined bullion totaled 2.54 million ounces valued at $305.89

Table 2.—U.S. monthly gold selling prices, per troy ounce

Month	1976		
	Average	Low	High
January	$131.99	$125.10	$140.85
February	131.56	129.25	133.90
March	133.08	129.20	134.75
April	128.43	127.70	129.70
May	127.44	125.00	128.95
June	126.21	124.20	127.90
July	118.00	108.25	123.80
August	110.09	103.05	114.05
September	114.67	106.20	120.40
October	116.64	114.50	123.65
November	131.38	123.10	139.35
December	134.38	131.00	138.15
Year	125.32	103.05	140.85

Source: Englehard Industries.

million. Major nonmonetary exports by destination and quantity were, in million ounces: The United Kingdom, 1.46; Switzerland, 1.20; Canada, 0.19; and West Germany, 0.11. The remainder of the gold exported was scrap and base bullion amounting to 0.34 million ounces valued at $41.6 million mainly going to Belgium (40%) and the United Kingdom (33%).

Gold imports totaled 2.66 million ounces valued at $331.0 million and consisted of 2.49 million ounces of refined bullion valued at $311 million, and 0.17 million ounces in ore, scrap, and base bullion valued at $20 million. Imports were 60% from Canada, 14% from Switzerland, 4% each from Argentina, Japan, the U.S.S.R., and Yugoslavia, and 10% from other countries. The average valuation of refined bullion imports was $124.92 per ounce. Gold contained in unrefined imports amounted to 166,312 ounces, 65% in ore and 35% in scrap and base bullion. Ores came from the Philippines (37%), Canada (31%), Australia (10%), and eight other countries (22%). Scrap and base bullion came from Canada (17%), Nicaragua (15%), Singapore (13%), Venezuela (12%), and 23 other countries (43%). In addition, an estimated 1.33 million ounces was imported in the form of gold coins compared with 1.67 million ounces in 1975. In addition to imports, the gold markets were supplied with 2.13 million ounces of bullion from foreign government stocks on deposit at the Federal Reserve Bank in New York City.

The net inflow of gold to U.S. markets, exclusive of monetary movements but including supplies from foreign and IMF stocks in New York, amounted to 4.99 million ounces in 1976 compared with 0.55 million ounces in 1975.

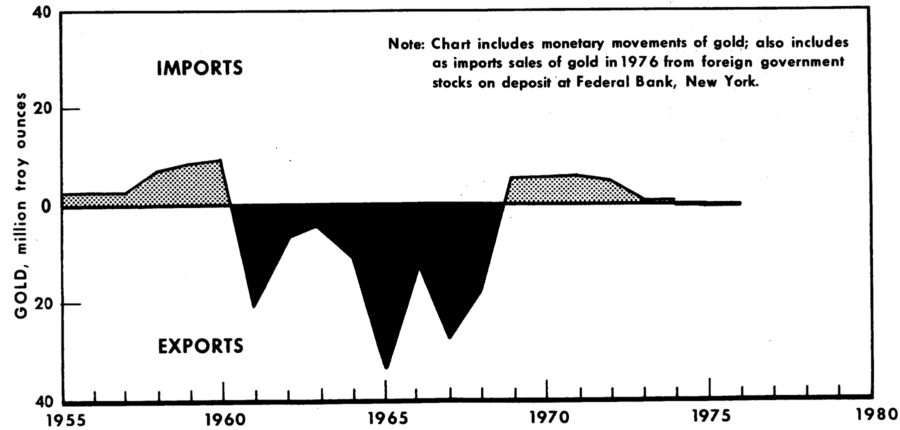

Figure 4.—Net exports or imports of gold.

WORLD REVIEW

Despite a 1% drop in gold production in the Republic of South Africa, world production was higher in 1976, with increases in byproduct production generally and in output from the U.S.S.R. and the Dominican Republic. Available information on the

U.S.S.R. mining indicated that lode mines were contributing most of the increase and placer mining may have had some setbacks. A new mine, the Pueblo Viejo, in the Dominican Republic, operated at capacity during the year and expansion was planned. The Pueblo Viejo became the Western Hemisphere's largest gold producer, exceeding the output of the Homestake mine in South Dakota by 30%.

According to the annual review of Consolidated Gold Fields Ltd., Gold 1977, the supply of gold to free markets increased 29% to 46.6 million ounces in 1976. Net bullion purchases for private speculation and investment amounted to 2.9 million ounces in 1976, about half that in 1975. Centrally-planned economies supplied 13.2 million ounces through trading, nearly triple the 1975 amount. Official sales and purchases netted 2.3 million ounces to supplies compared with 0.5 million ounces in 1975. An exceptional increase in imports of gold bullion and jewelry into the Middle East was reported, amounting to an estimated 12.9 million ounces in bullion and 2.6 million ounces in jewelry in 1976. The large offtake was explained by the great expansion in purchasing power throughout the Middle East area. In December, the United Kingdom reported receipt of 2.6 million ounces of gold bullion from the People's Republic of China, believed to have been shipped primarily to obtain foreign exchange. Net purchases of gold for fabrication were broken down into the following categories (with revised 1975 figures for comparison in parentheses), in million ounces: Karat jewelry, 30.1 (16.4); electronics, 2.3 (2.1); dentistry, 2.3 (2.1); other industrial and decorative uses, 2.0 (1.8); medals, medallions, and counterfeit coins, 1.3 (0.6); and official coins, 5.7 (7.8). Purchases for fabrication were also classified as follows, in million ounces: Developed countries, 26.5 (22.6) and developing countries, 17.2 (8.1). The leading countries in gold fabrication were as follows, in million troy ounces: Italy, 6.1 (2.6); the United States, 4.4 (3.8); Turkey, 3.7 (1.8); the Republic of South Africa, 3.0 (5.6); Japan, 2.9 (2.4); West Germany, 2.2 (1.8); Iran, 1.9 (0.9); Spain, 1.6 (1.4); Saudi Arabia and Yemen, 1.3 (0.4); Kuwait and Arabian Gulf States, 1.3 (0.5); France, 1.2 (1.1); Indonesia, 1.1 (0.5); and India, 1.1 (0.8). Gold used in official coins in 1976 was estimated to have declined 27% to 5.7 million ounces. Use in coins declined 48% to 2.9 million ounces in the Republic of South Africa, tripled to 0.9 million ounces in Austria, rose 46% to 0.5 million ounces in Mexico, and rose 6% to 0.5 million ounces in Turkey. A large increase in demand for small gold bars was indicated in the Far East. Italy was the largest consumer of gold in karat jewelry (5.69 million ounces), followed by Turkey (3.24 million ounces); Japan was the largest in electronics (0.74 million ounces), followed by the United States (0.70 million ounces); and the United States was largest in dental use (0.65 million ounces) and in other industrial and decorative uses (0.88 million ounces). Kuwait was the major consumer in medals and medallions (0.51 million ounces).

Following is a brief review of gold activities by country:

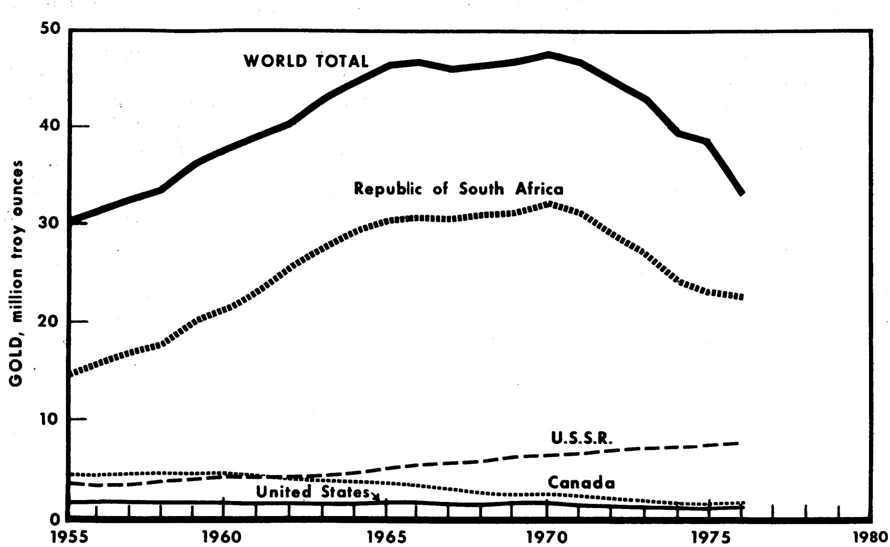

Figure 5.—World production of gold.

Australia.—Production continued to decline in 1976, with several major mines closing or about to close because of costs and a price drop in gold. Removal of a gold mining tax exemption was delayed, and the Industries Assistance Commission was asked to report by March 31, 1977, on the need to make changes in aid available to gold producers. The Australian Government reintroduced accelerated writeoffs for mining firms which was expected to benefit gold development. Projects were also made more attractive to overseas investment by a 17.5% devaluation of Australia's dollar in 1976.

Operations of Kalgoorlie Lake View Pty., Ltd. were scheduled for closing in November 1976, and the Mt. Charlotte mine was to be placed on care and maintenance. This was despite the purchase of a 48% interest in the firm in December 1975 by Homestake Mining Co. (United States) to infuse additional funds. During the financial year ending June 30, 1976, the operations produced 20% less ore, but at a 9% higher grade, than in the corresponding period a year earlier. A cleanup of the Chaffers treatment plant provided 7,162 ounces. The net result after milling was a 13% drop in gold production. Proved ore reserves reported in mid-1975 were 5.2 million tons grading 0.17 ounce per ton. Of this 63% was free-milling and the rest was refractory. At yearend, a plan was under consideration to rejuvenate the Mt. Charlotte mine with a $3 million investment in plant modifications, and closure was delayed.

Western Mining Corp. continued operations at the Norseman gold mine where high-grade ores remained profitable even at lower gold prices. Further exploration at the Jabiluka gold-uranium property of Pancontinental Mining Ltd. and Getty Oil Development Co. disclosed an ore body of 0.45 million tons indicated reserves averaging 0.47 ounce per ton and an additional 0.13 million tons inferred averaging 0.36 ounce per ton. Metallurgical tests showed 96% recovery was possible. Australian Anglo-American Pty., Ltd. began production at its Blue Spec mine in the Pilbara region of Western Australia in mid-1976. Most of the gold was said to occur in aurostibnite, an antimonial gold-arsenic compound that is metallurgically difficult to treat. About 88,000 tons of ore grading 1.34 ounces per ton of gold and 4.6% antimony were proven and further underground exploration was in progress. Development of the Telfer mine by Newmont Pty. (70%) and Dampier Mining Co. Ltd. (30%) was interrupted at midyear by a strike. The $35 million project was scheduled for completion in early 1977. The deposit, in the Paterson Range east of Port Hedland, Western Australia, had reserves of 4.2 million tons averaging 0.28 ounce per ton in gold, available by open pit mining.

Austria.—On October 22, Austria issued its first new gold coin in nearly 40 years and sold out the entire 1 million coin issue the same day. The fine gold content of the 900 fine coin was 0.434 troy ounce, and its face value was 1,000 shillings (about $58.00).

Bolivia.—Much of Bolivia's potential gold producing areas remained under Government control and unexploited as a "fiscal reserve." Production was increased with almost all of the increase coming from placer mining on the Tipuani and Kaka Rivers. The Tipuani was mined in the middle and upper reaches by gold mining cooperatives and by a dredge operation of South American Placers Inc. at the junction of the Tipuani and Kaka Rivers. Existing concessions were nearing depletion. The Banco Minero purchased gold from cooperatives and individual miners and sold it to jewelers and the Central Bank. Bolivia's Central Bank reserves at the start of 1976 were 409,499 fine ounces, 93% held in Bolivia. The Bolivian Geological Service began a 2-year exploration program on the Tuichi River in the Apolo area, Franz Tamayo sector of the Department of LaPaz, utilizing West German technical and financial assistance. New Jersey Zinc Co. was engaged in a joint venture on the mid-Tipuani River with El Camino Mines Ltd. (Canada); S. J. Groves Co. was developing a property on the lower Illichi River.

Brazil.—Ore reserves in Brazil contain an estimated 1.8 million ounces of gold, according to Government sources, about two-thirds in deposits in Minas Gerais. Production by Mineração Morro Velho S.A., owned by Anglo-American Corp. of South Africa Ltd. (49%) and Calmi Co. (51%), was scheduled to increase from 40,000 to 50,000 tons per month. A long term expansion was dependent on reevaluation of reserves. The ore grade was 0.225 ounce per ton.

British Solomon Islands.—The gold content of copper concentrates shipped from Bougainville in early 1976 was 1.05 ounces per ton.

Cameroon.—The source of placer gold in eastern Cameroon was to be investigated under a contract approved by the National Assembly.

Canada.—Gold production rose for the first time since 1961 and was 1.69 million ounces valued at $207.8 million in 1976 compared with 1.65 million ounces and $270.8 million in 1975. Higher grade ore was produced at a few lode mines as a necessity because of the drop in gold prices during the year, and some marginal gold mines were either closed or forced to reassess their financial positions. At yearend, 22 gold mines were active accounting for 73% of production. During the year two new mines opened and two mines closed. Canada's Emergency Gold Mining Assistance Act expired on June 30, 1976. It had become ineffective at higher prices. Minting of legal-tender gold coins was permitted under an amendment to the Olympic (1976) Act, and 14 and 22 karat coins were minted for sale at $105 and $150. The issue was limited to 1 million pieces.

According to preliminary data, gold output by Province, in thousand ounces (with percent change from 1975 in parentheses), was: Ontario, 734 (down 3%); Quebec, 474 (up 4%); Northwest Territories, 188 (up 7%); British Columbia, 177 (up 13%); Manitoba, 46 (down 4%); Yukon Territory, 31 (down 3%); Saskatchewan, 19 (up 30%); Newfoundland, 13 (unchanged); New Brunswick, 4 (up 18%); Alberta and Nova Scotia, minor production. Quartz lode and placer deposits supplied nearly 75% of all primary gold. Placer mining was a minor contributor and took place in the Yukon and British Columbia.

In Ontario, the source of 44% of Canadian gold in 1976, the Provincial Government sought Federal aid for gold mines in financial trouble owing to low gold prices. Eight out of 10 of Ontario's producing mines were in jeopardy, threatening 2,500 jobs. Pamour Porcupine Mines Ltd. planned to phase out lower grade operations at its five producing mines in the Timmins area, northern Ontario. Although Pamour's production rose in the first half of 1976, losses also rose and totaled $2.5 million for that period. At the beginning of 1976 ore reserves were 4.2 million tons grading 0.04 to 0.22 ounce of gold per ton. Plans were made to close the Ross mill and to center milling at the Schumacher mill. Bulora Corp. planned to close its Madsen mine at Red Lake because of mounting costs. Dickenson Mines investigated a significant new ore occurrence below the 30th level on the Dickenson and Robin properties in the Red Lake district and made smelter improvements. Rengold Mines Ltd. brought the Renabie gold mine into production in January but closed it in June because of financial problems. Northeast of Timmins, Intex Mining Co. Ltd. explored two gold-bearing zones averaging about 0.2 ounce per ton. Amoco Canada Petroleum Co. planned to drive a 2,500-foot decline, crosscut 1,000 feet, and perform 20,000 feet of diamond drilling at its Detour Lake gold discovery in northeastern Ontario.[9] Previous drilling of 136,000 feet in 129 holes outlined 10 million tons of ore expected to average 0.204 ounce per ton milling grade. Campbell Red Lake Mines, one of Canada's most profitable gold mines, produced 133,971 ounces from 225,000 tons of ore in the first 9 months of 1976, versus 133,990 ounces from 222,196 tons of ore in the comparable period in 1975. Net income for 1976 was $7.2 million compared with $11.1 million in 1975, and operating costs were reported at $47.02 per ounce, up 17.5% for the year.

In Quebec, Sigma Mines (Quebec) Ltd. produced 16,453 ounces of gold from 109,878 tons of ore milled during the third quarter of 1976. Camflo Mines Ltd. deferred exploration and development in favor of completing mill expansion and shaft sinking. In the first half of 1976, Camflo bullion production rose to 46,230 ounces from 228,633 tons of ore, and operating costs rose 15% to $59.85 per ounce compared with the first half of 1975. East Malartic Mines Ltd. production rose to a record 55,000 tons per month, and costs were reduced to $103.44 per ounce of gold. The company was preparing to reopen the Barnat mine. Teck Corp.'s Lamaque mine was phasing out operations. Belmoral Mines Ltd. planned production from the B zone at its Val d'Or, Quebec gold property where ore reserves were on the order of 1 million tons averaging 0.18 ounce per ton. Quebec Sturgeon River Mines Ltd. suspended work on potential new operations at Bachelor Lake, northwestern Quebec, and in Stock Township, northern Ontario, because of a shortage of cash to finance activities.

In the Northwest Territories, Giant Yellowknife Mines Ltd. reduced spending, lowered production costs, and increased output to 54,078 ounces during the first half of 1976, 17% above that of the comparable 1975 period. Exploration was cut in half. A net loss of $633,000 was reported in the first

[9]The Northern Miner. Amoco Goes Underground on Defour Gold Find. V. 62, No. 33, Oct. 28, 1976, pp. 1-2.

half of 1976. Cominco Ltd. settled a long strike at its Con gold mine at Yellowknife and continued an expansion program. Rayrock Mines Ltd. announced postponement of development at its Camlaren gold property near Yellowknife because of rising costs. In British Columbia, Northair Mines Ltd. began production near Brandywine Falls and milled about 300 tons of ore per day. Mill heads averaged nearly 0.4 ounce of gold per ton in May. During October, 4,300 ounces of gold was produced and mill recovery rates had reached 88% of gold in the ore. Claymore Resources reported pilot production of 300 to 500 cubic yards per day at its Laduc River district gold placer properties on the Alaska-Yukon border. Samples from one area on Kenyon Creek were said to average $20 per yard over a 6-foot thickness.

Chile.—St. Joe Minerals Corp. was developing a gold property at El Indio in the Coquimbo area. Arsenic in the ore was expected to be a problem.

Colombia.—Frontino Gold Mining Co., owner of the Vera, Cecilia, and Silencio gold mines, declared bankruptcy in late 1976 after reporting an expected $2 million loss for the year. Mineros de Antioquia S.A. (formerly Pato Gold Dredging Co.) was planning to purchase another dredge. Several small mines were opened in Nariño and Tolma.

Costa Rica.—Aquacate Consolidated Mines planned to reopen the Sacra Familia and Compania gold mines in early 1977 initially at 100 tons per day. Compañia Minera Esperanza S.A., owned by Bulora Corp. Ltd. and Brafor Capital Corp., temporarily suspended production at its gold property.

Dominican Republic.—Rosario Resources Corp. and J. R. Simplot Co. reached agreement with the Dominican Republic Government in December 1976 to sell a 13% participation each in Rosario Dominicana, S.A., which operates the Pueblo Viejo gold mine in Sanchez Ramirez Province. Each company received $3.7 milion for their shares. Also, a new 5% mining tax was expected to be levied against net income from gold and silver mining. Plans to develop the adjoining Los Cacaos gold property were delayed pending further studies. The Pueblo Viejo mine produced at full capacity in 1976. Output in dore bullion was 413,788 ounces of gold and 907,318 ounces of silver from ores averaging 0.155 ounce of gold and 0.448 ounce of silver per ton.

India.—Indian gold production was entirely from public sector mines of Bharat Gold Mines Ltd., under control of the Indian Department of Mines and from the Hutti Gold Mines Co., Ltd., under control of the Karnataka State Government. India's gold ore reserves have been estimated at 5.5 million tons containing 1.47 million ounces, 78% in the Kolar gold fields and 22% in the Hutti deposits. New reserves were found in the Ramagiri gold fields, Anantpur district, Andhra Pradesh, and additional exploration was underway at the Mysore and Nundydroog gold mines. Bharat Gold Mines production costs were reported in 1974-75 at $196.55 per troy ounce, remaining about the same in 1976. The Indian Government purchased production at a much lower price but provided a mining subsidy, which in 1975-76 amounted to $7.4 million. Gold was sold to domestic consumers at prices based on the Bombay market, which near the end of October 1976, were about $207 per ounce (exchange rate Indian Rs8.50=US$1.00). Smuggling of gold into India continued because of the spread between domestic and international prices.[10] The Indian Geological Survey planned to acquire a ship from West Germany to use in exploring for gold on the ocean floor off the mouths of the Mahanadi and Subarnarekha Rivers in Orissa State and other rivers to the South.

Indonesia.—A number of firms, mostly domestic, explored for gold in Sumatra, Kalimantan, and West Java. A subsidiary of Australian Endeaver Oil Co. explored in Gorontalo of North Sulawesi. P. N. Arneka Tambang explored an area in Central Sumatra near Logas and continued production of gold and silver at its Cikotok mine in West Java. A ban remained on gold exports, and imports faced a 30% duty. The gold content of copper concentrate exported from West Irian operations of Freeport Indonesia Ltd. averaged about 0.28 ounce per ton.

Ivory Coast.—The Pennaroya Mokta consortium completed a study of the Ity gold mine where ores averaged about 0.35 ounce of gold per ton.

Japan.—Consumption of gold was estimated in the fiscal year ending April 1976 at 3.4 million ounces; 35% in jewelry, 11% in dental and medical uses, 13% in gold plating, 9% in communication and machine

[10]U. S. Embassy, New Delhi, India. State Department Airgram A-344, Dec. 30, 1976, pp. 21-24.

parts, 5% in industrial art products, and the rest in miscellaneous uses.[11]

Liberia.—Azuza Mining Co. ivestigated lode gold concessions on the Cavalla River, near the Ivory Coast border. A $2 million investment in a mining operation was under consideration.

Mali.—Technicians from the U.S.S.R. assisted in the construction of a gold mining facility at Kalma. Production was scheduled by yearend.

Mexico.—Cia. Minera Las Torres S.A. began operation of a 2,000-ton-per-day mill at Guanajuato, Mexico, in March 1976 treating silver-gold ores from the Las Torres, Peregrina, Cebada, and Bolanitos mines.[12] The average ore grade was 12.2 ounces of silver and 0.08 ounce of gold per ton with metal recoveries averaging 90% for silver and 92% for gold. The company was owned 30% by Lacana Mining Corp., 37% by Cia. Fresnillo S.A., and 33% Industrias Penoles S.A.

Nicaragua.—A 25-ton-per-day mill was under construction at the Santa Rosa gold-silver property of Minas de Cerro Dorado in eastern Nicaragua and expansion to 100 tons per day was considered. The general ore grade was expected to range between 0.5 and 1 ounce per ton in gold and 5 and 10 ounces in silver. The company also was preparing for a small gold placer operation nearby.

Papua New Guinea.—Bougainville Copper Ltd. produced virtually all the island's gold output as a byproduct of copper mining. A small gravel pump and gold sluicing operation of New Guinea Goldfields was active on Edie Creek southwest of Wau. New Guinea Goldfields also operated a small open pit mine at Golden Ridge, northwest of Qau, where ore reserves of about 0.5 million tons were estimated to grade 0.07 to 0.09 ounce per ton. During the fiscal year ending June 30, 1976, the latter deposit produced 8,955 ounces of gold and 9,464 ounces of silver. Exploration at the Ok Tedi copper deposit revealed an estimated 177 million tons of copper ore (0.8% copper), containing 0.02 ounce per ton of gold and a small amount of molybdenum. A 40,000-ton-per-day operation was contemplated.

Philippines.—The Philippines Central Bank's new gold refinery in Quezon City, Manila, was scheduled for completion by mid-May 1977. Refining capacity was planned for 600,000 ounces of gold and 450,000 ounces of silver annually. Benguet Consolidated, Inc., the largest gold producer, reported average production costs of $143 per ounce in the third quarter of 1976, $27 per ounce higher than the comparable period of 1975, and indicated that it might cease operations because of mounting losses. Philippine gold producers sought a Government guarantee of $160 per ounce on their output, but late in 1976 the Government had not acted on a petition to reinstitute gold subsidies. However, the Governor of the Philippines Central Bank authorized creation of a Gold Market Committee to help establish a Domestic Gold Exchange. Atlas Consolidated Mining & Development Corp. planned to reactivate a gold mine at Aroroy, Masbate, and build a 3,000- to 4,000-ton-per-day mill facility. Apex Exploration and Mining Co. was expanding production capacity from 300 tons per day to a scheduled 1,000 tons per day in early 1977, based on discoveries in Masara, Davao. Metals Exploration Asia completed feasibility studies on a potential 800-ton-per-day gold operation near Longos, Paracale, where reserves of 1.3 million tons averaging 0.51 ounce of gold per ton were indicated by diamond drilling. Golden River Mining Corp. was building an 8,000-cubic-yard-per-day bucket dredge for its gold property in Paracale, southern Luzon, where placer reserves are estimated between 21 and 50 million cubic yards.

Saudi Arabia.—A study by the U.S. Geological Survey concluded that the Mahd adh Dhahab mining district between Mecca and Medina was an important source of the biblical King Solomon's gold.[13] In September, Gold Fields Mahd adh Dhahab Ltd., a Consolidated Gold Fields Ltd. subsidiary, obtained an exploration license from the Saudi Arabian Government to investigate the area in a joint venture with the General Petroleum and Mining Organization.

South Africa, Republic of.—Gold output was virtually the same as in 1975 when 22.9 million ounces was produced. All mine production was refined at Rand Refinery, Inc. facilities in Germiston, Transvaal. According to the December Analysis of Working Results by the Chamber of Mines of South Africa, member companies milled 76.2 million tons of ore to produce 22.8 million ounces of gold. The average grade, including

[11]Japan Metal Bulletin. Estimated Demand and Supply of Gold for FY 1976. V. 6, No. 37, Sept. 13, 1976, pp. 6-7.

[12]Fish, R. Lacana Mining Helps Continue 450-Year Mexican Mining History. Can. Min. J., v. 97, No. 1, January 1976, pp. 43-47.

[13]U.S. Geological Survey. King Solomon's Gold Mine Rediscovered? Department of the Interior News Release, May 24, 1976, 4 pp.

ores of byproduct producers of uranium, was 0.30 ounce of gold per metric ton (0.27 ounce per short ton). The largest producing mine was the Vaal Reefs, with output of 2,122,107 ounces; the West Driefontein was second with 1,792,545 ounces. The West Driefontein and East Driefontein mines were the richest, with mill grades averaging 0.73 and 0.65 ounce of gold per ton. Byproduct uranum production amounted to 618 million pounds U_3O_8 from treatment of 17.3 million tons of gold-uranium ore, the grade averaging 0.4 pound U_3O_8 per metric ton (0.36 per short ton). Uranium was produced from eight mines, the most important of which were the Vaal Reefs, Buffelsfontein, Harmony, and Hartebeestfontein. Sulfuric acid or pyrite was produced at 11 mines as another byproduct. State assistance for gold mining was received by 10 producers; the largest recipient was East Rand Proprietary Mines, Ltd. followed by Durban Roodepoort Deep, Ltd. and Loraine Gold Mines Ltd.

Reserves of gold ore were reported at 199.7 million tons averaging 0.414 ounce per metric ton (0.38 per short ton) fully developed and blocked out on January 1, 1976, (based on gold price and operating costs on that date). There were large additional reserves of indicated and inferred categories of ore. The largest tonnages were at the Harmony, Vaal Reefs, St. Helena, and Hartebeestfontein mines. The highest grade was 1.01 ounce per ton for 2.77 million tons in the Ventersdrop Contact Reef of the East Driefontein mine.

Three major new mines continued under development, the Unisel mine of Union Corp. in the Orange Free State, the Deelkraal mine of Gold Fields of South Africa, and the Elandsrand mine of Anglo American Corp.; both of the last two are south of Carletonville in the Far West Rand. By yearend 1976, the Unisel main shaft had reached a depth of 5,100 feet and production plans for 1978 remained on schedule. The other mines were to begin producing in 1980-81 and were being rushed to completion. At the Elandsrand, underground development was conducted from the adjoining Western Deep Levels mine to accelerate progress. Shaft sinking methods were also improved. By yearend an ore and ventilation shaft had reached 4,100 feet and a smaller diameter men-and-supplies shaft was to a depth of 5,100 feet. The two shafts were to bottom at about 7,586 feet in early 1979. Minable reserves at Elandsrand were estimated at 66 million tons averaging 0.38 ounce of gold per ton. The cost of bringing the Elandsrand mine into production at 180,000 tons per month was estimated at $168 million (1975 dollars). Two shafts at the Deelkraal mine reached 5,500 and 5,300 feet in depth at yearend. A proposal was reported for President Steyn Gold Mining Co. Ltd. and Sentrust Ltd. to develop and mine the Video No. 305 property in the Ventersburg district of the Orange Free State.[14] Video Mining Co. Ltd. was formed as a subsidiary of President Steyn to implement agreements and act on the results of a feasibility study scheduled for completion in December 1979.

A number of uranium byproduct facilities were under construction or planned in the Republic of South Africa. The President Brand Gold Mining Co. Ltd. opened a large rehabilitated byproduct complex to treat residues from Anglo American Corp. mines in Orange Free State. Mines to supply tailings included the President Brand, President Steyn, Free State Geduld, Welkom, Western Holdings, Free State Saaiplaas, and Freddies. Tailings were to be treated by flotation at 1.5 million tons per month, with expected recoveries of 50% of the uranium, 20% of the gold, and 85% of the pyrite contained. At the Harmony mine, in the Orange Free State, plans were made to expand operations and supply tailings to a new uranium extrction facility planned at Merriespruit and an expanded unit at Virginia. A 180,000 ton-per-month plant to extract uranium from residues was opened at the Welcom mine.

Randfontein Estates Gold Mining Co. Ltd., considered the feaibility of building a new gold and uranium extraction plant near its active Cooke No.2 shaft and reopening part of its old Randfontein mine in a project estimated to cost $150 million.[15] Uranium slimes, to be treated at the mill site, were expected to grade about 0.3 to 0.4 pound per ton with recoveries of 90% to 94%.[16] The Anglo American group continued studies of a large complex to process slimes from old East Rand mines, possibly by 1978. A new company was to be formed—East Rand Gold and Uranium Co. Ltd.

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[14]Mining Magazine (London). South Africa Gold Mine Extension Terms. V. 134, No. 9, September 1976, p. 191.

[15]Mining Magazine. Randfonstein's Cooke Section - A New Gold Mine for a Famous Old Producer. V. 134, No. 4, April 1976, pp. 161-167.

[16]Mining Magazine. South African Gold Mines Uranium Production Plans. V. 134, No. 8, August 1976, pp. 103, 105.

According to spokesman for Anglo American Corp. of South Africa Ltd., uranium was becoming much more important in South African gold mining, and output could reach 17 to 18 million pounds per year in the next decade.[17] Profits from uranium in gold mines were $37 million in the first 9 months of 1976 but only $1.2 million in 1975. It was estimated that South African annual gold production would be between 23 and 26 million ounces in the coming decade but was on the last plateau before a long decline. Methods of increasing gold mining productivity in South African mines were considered.[18] The South African Mine Workers Union and Chamber of Mines agreed to initiate an 11-shift fortnight (5 days, 1 week and 6 days the next) beginning in April 1977. Labor shortages continued to be a serious problem in South Africa's gold mines limiting output growth.

Sudan.—The Sudanese Government signed an agreement with a United Kingdom firm to study and design a gold mining operation in the Serkawit region of the Red Sea Hills.

Surinam.—An estimated reserve of 70 million tons of low-grade gold ore averaging about 0.05 ounce per ton was developed in the Brokopondo area of Surinam by a Canadian firm and the Surinam Government in a joint venture.

U.S.S.R.—According to estimates of the U.S. Central Intelligence Agency, the U.S.S.R. was expected to sell 0.8 million ounces of gold per month in 1977, rising to 0.9 million ounces per month in 1978. Earnings from gold sales in 1976 were estimated at $1 billion. The information was published by the Agency in a report entitled U.S.S.R.: Hard Currency Trade and Payments 1977-78. In a prediction by a Canadian author, U.S.S.R. gold production was expected to surpass that of the Republic of South Africa in the late 1980's.[19] Production of the chernovetz, a U.S.S.R. coin containing 0.25 ounce of gold, was higher than the 250,000 minted in 1975 and was expected to exceed 1 million in 1977.

Venezuela.—The Government was investing heavily in eastern Guayana mines and planned expansions from 15,500 ounces to 165,000 ounces per year in 1980. The State-owned mining company, Minervén, planned to reactivate the El Callao gold mine, which contained estimated reserves of 2.5 million tons grading 0.7 ounce per ton in gold.

TECHNOLOGY

Twenty or more gold-leaching operations were in production or under development in the western United States during 1976 as a result of research initiated by the Bureau of Mines. Most properties had relatively small outputs, and activities tended to be intermittent. Mine owners viewed the new leaching technology as an opportunity to recover gold from shallow, low-grade deposits, or from mine wastes and tailings, with a minimum of capital investment in mine and plant facilities. Essentially, the heap leaching technique consisted of placing a low heap of gold-bearing material, either crude or partially crushed, on an impervious base, such as asphalt or plastic sheets; distributing a cyanide solution over the surface, collecting the gold-bearing solution in a sump, and extracting the gold with activated carbon. Gold was then stripped from the carbon by a hot caustic cyanide solution, or, in an improved method, by a hot alkaline-alcohol solution, electrodeposited on steel wool, and finally melted into bars. Additional studies showed that any silver values extracted in cyanidation could best be recovered by simple precipitation of the silver as a sulfide, using sodium sulfide before the carbon extraction of the gold.

Heap leaching was believed practicable on ores containing as little as 0.03 ounce of gold per ton of ore providing sufficient tonnages were available and the gold recovery factor was high. Also, the heap leach technique was applied with apparent success by at least one Nevada operator to extract silver, using the sulfide precipitation step, from low-grade silver-gold ore and dump material containing only minor amounts of gold. In general, silver has been more difficult to leach than gold, owing to complex mineral associations and slower extraction rates. Further studies were being conducted at the Reno Metallurgy Research

[17] American Metal Market. South Africa Gold Production Seen Skidding in Late 80's. V. 82, No. 233, Dec. 2, 1976, p. 8.

[18] Engineering and Mining Journal. Special Problems Curb Productivity Gains in South Africa's Gold Mines. V. 177, No. 10, October 1976, p. 25

[19] Northern Miner. Russia to Overtake South Africa's Output. V. 62, No. 10, May 20, 1976, pp. 1, 4.

Center, Federal Bureau of Mines, Reno, Nev.

A mobile demonstration unit, designed to show by field tests the efficiency of the alkaline-alcohol gold stripping method, was tested at a number of locations and resulted in adoption of the method by several operators including the Homestake Mining Co., where tests showed stripping time could be reduced from 100 to 5 hours. Homestake has been recovering gold from mill slimes since August 1973 by a carbon-in-pulp method developed by the Bureau of Mines. Bench-scale tests were conducted to determine feasibility of reusing the activated carbon after it was stripped with alkaline-alcohol solutions without the usual thermal reactivation step. Through at least four cycles of loading and stripping it was feasible to recover gold from a refractory, carbonaceous ore by a modified heap leaching technique. The system included pretreatment with a hypochlorite solution to destroy organic matter which interferes with gold recovery. A 10% sodium chloride solution containing hypochlorite, generated by electrolysis in situ, was percolated through the ore bed until exposed carbonaceous matter was oxidized. The ore was then leached with a cyanide solution adjusted with lime to pH10.5, but the ore became impermeable. Research continued using other oxidants. Studies also were in progress on effects of flocculating and wetting agents on solution percolation rates in heap leach cyanidation. In other tests, electrooxidation treatment of several carbonaceous gold ores in a commercial 125-volt, 1,000-ampere bipolar flow-through cell increased extractions in subsequent cyanidation from about 72% to 90%.

A patent was issued on the process of recovering absorbed gold and/or silver from activated carbon using alcohol or ketones alone or in aqueous solution with a strong base to facilitate elution.[20] The Bureau of Mines awarded a contract to the University of Utah during 1976 to study the kinetics and thermodynamics of the gold cyanide-silver cyanide-carbon reaction. Battelle Northwest Laboratories scheduled an 18-month study to identify organic compounds in carbonaceous gold ores and the composition of surface films on gold in refractory-type ores. A publication described various analytical methods for gold and a list of commercial assay laboratories.[21] Assistance was provided to the Defense Supply Agency by Bureau of Mines specialists in identifying gold-bearing scrap from obsolete electronic and other military equipment. Gold in scrap electronic solders was recovered by drossing with aluminum or zinc in a process developed by the Bureau.[22] Drossing upgraded the product by a factor of 10; further concentration was achieved by roasting, amalgamation, and leaching. A Battelle Columbus Laboratories study of energy inputs to mineral processing showed that the energy required to produce a new ton of refined gold was 58,855 million British thermal units (Btu's).[23] Details of energy requirement by process step were provided.

Gold was extracted from a low-yield gold ore by electrolysis of a salt solution of the pulp[24] and from gold-plated scrap or ore by treatment with an aqueous solution of iodine and potassium iodide followed by sulfur dioxide, hydroxylamine, or hydrazine precipitation of the gold.[25]

An air pollution problem caused by arsenic in gold ores was eliminated by Campbell Red Lake Gold Mines in Ontario, Canada. Gas from the roaster plant was passed over precipitator collector plates where calcine dust collected; arsenic continued on to an air mixing chamber. There a temperature drop to 250°F caused precipitation and the arsenic was caught in a baghouse.[26] Also in Canada, a graphite-bearing gold ore was successfully treated by first extracting the graphite by flotation and after pyrite and gold flotation, ending with cyanidation.[27] Recoveries doubled to the 85% to 93.6% range. The effectiveness of ammonium chloride in gold milling was described.[28] Among its uses were: Cleansing agent in amalgamation, complexing agent against dissolution of copper, and sequestering agent to minimize scale formation in a lime-cyanide circuit.

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[20]Fisher, D. (assigned to U. S. Department of the Interior). Process for Eluting Absorbed Gold and or Silver Values from Activated Carbon. U.S. Pat. 3,935,006, Jan. 27, 1976.

[21]Heady, H. H. and K. G. Broadhead, Assaying Ores, Concentrates, and Bullion. Revision of Information Circular 7695. BuMines IC 8714, 1977, 26 pp.

[22]Ferrell, E. F. Recovering Gold from Scrap Electronic Solders by Drossing. BuMines RI 8169, 1976, 9 pp.

[23]Battelle Columbus Laboratories. Energy Use Patterns in Metallurgical and Nonmetallic Mineral Processing (Phase 6—Energy Data and Flowsheets, Low Priority Commodities). BuMines Open File Rept. 117(1)-76, 1976, pp. 101-106; available for consultation at Bureau of Mines facilities in Tuscaloosa, Ala.; College Park, Md.; Twin Cities, Minn.; Rolla, Mo.; Boulder City and Reno, Nev.; Albany, Oreg.; Salt Lake City, Utah; the National Library of Natural Resources, U. S. Department of the Interior, Washington, D.C.; and from National Technical Information Service, Springfield, Va., PB 261 150/AS.

[24]Rhodes, W. A. (assigned to Electromet Inc.). Electrochemical Extraction of Gold From a Low Yield Ore. U. S. Pat. 3,957,603, May 18, 1976.

[25]Homich, R. P., and H. Sloan (assigned to Bayside Refining & Chemical Co.). Extraction of Gold from Gold-Plated Scrap or Gold Ore. U. S. Pat. 3,957,505, May 18, 1976.

[26]Canadian Mining Journal. Air Pollution Brought Under Control. V. 97, No. 3, March 1976, p. 27.

[27]Raicevic, D., and R. W. Bruce. Gold Recovery From a Refractory Carbonaceous Gold Ore. Can. Min. J., v. 97, No. 3, March 1976, pp. 40-45.

[28]Roach, A. G. Ammonium Chloride Resolves Problems in Gold Metallurgy. Can. Min. J., v. 97, No. 9, September 1976, pp. 48-50.

The National Institute of Metallurgy in the Republic of South Africa investigated procedures for recovering uranium and gold from ores of the Witwatersrand using wet high-intensity magnetic separation on cyanidation residues. It was found that 50% of the residual gold and up to 70% of the total uranium could be recovered in the magnetic concentrates.[29]

Plans by Golden Cycle Gold Corp., for reopening its properties in the Cripple Creek district of Colorado were described.[30] Shaft rehabilitation work for access to the 3,100-foot level of the Ajax mine cost $300 per foot and required 10 months. A report discussed possible costs of in situ leaching of gold ores.[31]

Details of a fire in the Homestake gold mine were disclosed in a review of events that took place before and after.[32] The fire was in a timbered section on the 3,050-foot level and caused closure of the mine for 12 days.

South African efforts to overcome problems of high rock temperatures, high rock stress, narrow working places, and hardness and abrasiveness of rock mined were described.[33] Problems were being met by greater mechanization. For instance, a high-thrust raise-borer cut a 9-foot wide overpass at the Vaal Reefs South mine in a record time. A mechanized stope-cleaning system was developed around an armoured face conveyor and a new reciprocating flight conveyor was developed.[34] Successful trials were conducted in South African mines of specially designed twin-boom drill jumbos.[35] Installation of steel arches and tests of a new tunneling machine were described.[36]

Anomalous concentrations of gold were found in samples from unproductive zones similar in character to nearby productive zones in the Goldfield, Nev., area. Two associations of elements were found, one a relict hypogene association and the other supergene, the latter formed during oxidation.[37] Statistical analysis techniques were used to assess theories of the origin of the Carlin disseminated gold deposit near Carlin, Nev.[38] Gold and mercury values showed high correlations in all areas sampled.

Evidence was given to show that in the Witwatersrand gold field of South Africa a hitherto unknown form of plant life was instrumental in concentrating gold during the Precambrian period.[39] It was believed the discovery would help in developing a better geological model of deposits and improve assessment of gold distribution. Studies were made of gold in the Precambrian Vaal Reef Placer, the Republic of South Africa,[40] in stratabound deposits in Rhodesia,[41] and in certain stratigraphic units of the Abitibi supergroup in Canada.[42]

Gold was included with other precious metals in a report describing comparative physical characteristics and engineering properties.[43] The composition of anodic films formed on gold and rate of gold dissolution in electrolyzed sulfuric acid with and without chloride ions was the subject of a study.[44] Neutron activation analysis was found to be an excellent means of studying the variations in gold concentration on silicon wafers before and after phosphorous

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[29]Engineering and Mining Journal. South Africans Seek New Methods to Boost Recovery of Gold and Uranium. V. 28, No. 8, August 1976, pp. 122-123.

[30]Schwab, C. E. Reopening a Cripple Creek Gold Mine. Min. Cong. J., v. 62, No. 1, January 1976, pp. 19-24.

[31]Weiss, A. World Mining and Metals Technology. Proc. Joint MMIJ-AIME Meeting, Denver Colo., Sept. 1-3, 1976, v. 1, chap. 21, 1976, pp. 333-348.

[32]Waterland, J. F. Mine Fire-Homestake Mine, Lead, S. Dak.— May 9, 1975. The Colorado Mining Assoc., Mining Year Book 1976, pp. 145-156.

[33]Schumann, A.W.S. Present Methods of Gold and Coal Mining in South Africa and the Potential for Their Future Development. Proc. 9th World Min. Cong., the Federal Republic of Germany, May 1976, sec. 3 No. 20, 1976, 9 pp.

[34]Joughin, N.C., and A.C. Buckmaster. The Use of Face Conveyors in Gold Mines. J. S. African Inst. on Min. and Met., v. 76, No. 7, February 1976, pp. 315-324.

[35]Mining Magazine. Hydro-Percussive Drills. V. 135, No. 3, September 1976, pp. 194-205.

[36]Engineering and Mining Journal. South Africans Use Steel Arches to Brace Collapsed or Weak Crosscuts. V. 28, No. 7, July 1976, pp. 31, 35.

———.South African Test on New Tunneling Machine Reported at London Exposition. V. 28, No. 5, May 1976, p. 41.

[37]Ashley, R. P., and W. J. Keith. Distribution of Gold and Other Metals in Silicified Rocks of the Goldfield Mining District, Nevada. U.S. Geol. Survey Prof. Paper 843-B, 1976, 17 pp.

[38]Harris, M., and A. S. Radtke. Statisitical Study of Selected Trace Elements with Reference to Geology and Genesis of the Carlin Gold Deposit, Nevada. U. S. Geol. Survey Prof. Paper 960, 1976, 21 pp.

[39]Mining Magazine. Gold Concentration By Precambrian Plant Life. V. 135, No. 1, July 1976, pp. 21-24.

[40]Minter, W. E. L. Detrital Gold, Uranium, and Pyrite Concentrations Related to Sedimentology in the Precambrian Vaal Reef Placer, Witwatersrand, South Africa. Econ. Geol., v. 71, No. 1, January-February 1976, pp. 157-176.

[41]Fripp, R. E. P. Stratabound Gold Deposits in Archean Banded Iron-Formation, Rhodesia. Econ. Geol., v. 71, No. 1, January-February 1976, pp. 58-75.

[42]Ridler, R. H. Stratigraphic Keys to the Gold Metallogeny of the Abitibi Belt. Can. Min. J., v. 97, No. 6, June 1976, pp. 81-90.

[43]Miska, K. H. Precious Metals. Mater. Eng., v. 84, No. 5, November 1976, pp. 65-71.

[44]Frankenthal, R. P., and D. E. Thompson. The Anodic Behavior of Gold in Sulfuric Acid Solutions: Effect of Chloride and Electrode Potential. J. Electrochem. Soc., v. 123, No. 6, June 1976, pp. 799-804.

gettering.[45] In a two-part series on alloying, the formation of solid solutions of gold was explained in terms of atomic structures, and factors were considered affecting formation of compounds with other metals.[46] Effects of gold on biological systems and use in chemotherapy were reviewed.[47] The intake of gold in micro-organisms was shown graphically by pictures in which sites of gold deposition could be seen. Uses for gold drugs generally range from anti-inflammatory to anti-bacterial. Gold ketenide, one of a new class of organometallic compounds, was believed to have potential for use in selective oxidation catalysts.[48] Compounds formed when gold ketenide decomposed explosively were examined.

[45]Murarka, S. P. A Study of the Phosphorous Gettering of Gold in Silicon by Use of Neutron Activation Analysis. J. Electrochem. Soc., v. 123, No. 5, May 1967, pp. 765-767.
[46]Raynor, G. V. The Alloying Behavior of Gold: Part I. Solid Solutions; Part II, Compound Formation. Gold Bull., v. 9, No. 1, January 1976, pp. 12-19; v. 9, No. 2, April 1976, pp. 50-54.
[47]Sadler, P. J. The Biological Chemistry of Gold. Gold Bull., v. 9, No. 4, October 1976, pp. 110-118.
[48]Blues, E. T., D. Bryce-Smith, and I. W. Lawston. Gold Ketenide. Gold Bull., v. 9, No. 3, July 1976, pp. 88-90.

Table 3.—Mine production of recoverable gold in the United States, by State

(Troy ounces)

State	1972	1973	1974	1975	1976
Alaska	8,639	7,107	9,146	14,980	22,887
Arizona	102,996	102,848	90,586	85,790	102,062
California	3,974	3,647	5,049	9,606	10,392
Colorado	61,100	63,422	52,083	55,483	50,764
Idaho	2,884	2,696	2,898	2,529	2,755
Montana	23,725	27,806	28,268	17,259	24,075
Nevada	419,748	260,437	298,754	332,814	287,962
New Mexico	14,897	13,864	15,427	15,049	15,198
Oregon	W	W	W	W	28
South Dakota	407,430	357,575	343,723	304,935	318,511
Tennessee	176	68	18	W	W
Utah	362,413	307,080	254,909	189,620	187,318
Other States	41,961	29,200	26,025	24,187	26,085
Total	1,449,943	1,175,750	1,126,886	1,052,252	1,048,037

W Withheld to avoid disclosing individual company confidential data; included in "Other States."

Table 4.—Mine production of recoverable gold in the United States, by month

(Troy ounces)

Month	1975	1976
January	88,441	91,121
February	82,358	82,215
March	75,739	88,096
April	86,234	91,488
May	88,252	93,317
June	91,578	87,760
July	75,787	83,776
August	84,302	84,971
September	94,255	88,727
October	93,667	93,195
November	95,908	81,377
December	95,731	81,994
Total	1,052,252	1,048,037

Table 5.—Twenty-five leading gold-producing mines in the United States in 1976, in order of output

Rank	Mine	County and State	Operator	Source of gold
1	Homestake	Lawrence, S. Dak	Homestake Mining Co	Gold ore.
2	Carlin	Eureka, Nev	Carlin Gold Mining Co	Do.
3	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper ore.
4	Sunnyside	San Juan, Colo	Standard Metals Corp	Lead-zinc ore.
5	Copper Canyon	Lander, Nev	Duval Corp	Copper ore.
6	Knob Hill	Ferry, Wash	Knob Hill Mines, Inc	Gold ore.
7	Cortez	Lander, Nev	Cortez Gold Mines	Do.
8	Bootstrap	Elko, Nev	Carlin Gold Mining Co	Do.
9	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
10	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Do.
11	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
12	Magma	Pinal, Ariz	Magma Copper Co	Do.
13	Trixie	Utah, Utah	Kennecott Copper Corp	Gold-silver ore.
14	Atlanta	Lincoln, Nev	Standard Slag Co	Gold ore.
15	Nome Unit	Seward Peninsula, Alaska	Alaska Gold Co	Placer.
16	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper ore.
17	Blue Star	Eureka, Nev	Carlin Gold Mining Co	Gold ore.
18	Idarado	Ouray and San Miguel, Colo	Idarado Mining Co	Copper-lead-zinc ore.
19	Leadville Unit	Lake, Colo	ASARCO Inc	Lead-zinc ore.
20	Continental	Grant, N. Mex	UV Industries, Inc	Copper ore.
21	Pinto Valley	Gila, Ariz	Cities Service Co	Do.
22	Metcalf	Greenlee, Ariz	Phelps Dodge Corp	Do.
23	Oriental	Sierra, Calif	Dickey Exploration Co	Gold ore.
24	Windfall	Eureka, Nev	Idaho Mining Co	Do.
25	Heap Leaching	Cochise, Ariz	71 Minerals, Ltd	Do.

Table 6.—Production of gold in the United States in 1976, by State, type of mine and class of ore, yielding gold, in terms of recoverable metal

State	Placer (troy ounces of gold)	Lode: Gold ore		Lode: Gold-silver ore		Lode: Silver ore	
		Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	22,605	463	275	--	--	--	--
Arizona	--	W	W	W	W	16,408	193
California	4,847	5,536	5,005	2,225	440	--	--
Colorado	75	36,317	4,054	589	232	90,309	693
Idaho	--	91	66	72	42	466,762	1,036
Montana	16	6,866	3,106	5,121	525	67,890	565
Nevada	10	1,295,948	257,954	W	W	8,961	1,008
New Mexico	42	10,455	1,386	3,776	426	128	5
Oregon	28	--	--	--	--	--	--
South Dakota	--	1,658,132	318,511	--	--	--	--
Other States	--	49,081	26,010	1,014,738	23,365	120	5
Total	27,623	3,062,889	616,367	1,026,521	25,030	650,578	3,505
Percent of total gold	3	--	59	--	2	--	(1)

State	Lode: Copper ore		Lode: Lead ore		Lode: Zinc ore	
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	--	--	58	7	--	--
Arizona	158,425,522	97,636	--	--	--	--
California	--	--	--	--	W	W
Colorado	--	--	206	10	178,945	337
Idaho	W	W	187,697	1,003	W	W
Montana	16,780,752	19,843	W	W	--	--
Nevada	3,057,651	28,819	--	--	W	W
New Mexico	25,015,712	13,219	W	W	W	W
Oregon	--	--	--	--	--	--
South Dakota	--	--	--	--	--	--
Other States	29,707,679	166,224	4,221	226	173,135	144
Total	232,987,316	325,741	192,182	1,246	352,080	481
Percent of total gold	--	31	--	(1)	--	(1)

State	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Lode: Old tailings, etc.		Lode: Total[2]	
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	--	--	--	--	521	22,887
Arizona	91,378	343	40,985	223	159,514,318	102,062
California	--	--	W	W	10,061	10,392
Colorado	882,466	45,363	--	--	1,188,832	50,764
Idaho	1,094,239	590	--	--	1,921,290	2,755
Montana	--	--	W	W	16,861,116	24,075
Nevada	77,350	14	--	--	4,448,985	287,962
New Mexico	--	--	--	--	25,161,206	15,198
Oregon	--	--	--	--	--	28
South Dakota	--	--	--	--	1,658,132	318,511
Other States	2,780,736	1,404	37	[3]107	32,474,412	213,403
Total	4,926,169	47,714	41,022	330	243,238,873	1,048,037
Percent of total gold	--	5	--	(1)	--	100

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1]Less than 1/2 unit.
[2]Data may not add to State totals because of items withheld to avoid disclosing individual company confidential data.
[3]Includes byproduct gold recovered from tungsten ore in California.

Table 7.—Gold produced in the United States from ore, old tailings, etc., in 1976, by State and method of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc., treated[1] (thousand short tons)	Ore and old tailings to mills					Crude ore, old tailings, etc., to smelters[1]	
		Thousand short tons[1]	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Thousand short tons	Troy ounces
Alaska	1	1	--	--	7	275	(2)	7
Arizona	[3]195,242	[3]194,900	--	3,661	3,277,536	97,936	342	465
California	[4]10	[4]10	2,713	--	2,492	2,746	(2)	86
Colorado	1,295	1,294	13,502	3,649	152,025	33,303	1	235
Idaho	1,960	1,959	8	--	170,756	2,643	1	104
Montana	16,884	16,788	1,634	289	338,063	20,930	96	1,206
Nevada	[3 5]13,753	[3 5]13,712	350	258,544	201,133	28,665	41	393
New Mexico	[3]25,189	[3]25,106	--	969	788,429	13,339	83	848
South Dakota	1,658	1,658	--	318,511	--	--	--	--
Utah	30,053	29,937	--	--	723,132	167,772	116	19,546
Other States	5,252	5,252	--	1,917	250,537	24,116	(2)	52
Total	291,297	290,617	18,207	587,540	5,904,110	391,725	680	22,942

[1]Includes some nongold-bearing ores not separable.
[2]Less than 1/2 unit.
[3]Includes tonnages from which gold is heap leached.
[4]Excludes tonnage of tungsten ore from which gold was recovered as a byproduct.
[5]Includes tonnages from which gold is vat leached.

Table 8.—Gold produced at amalgamation and cyanidation mills in the United States and percentage of gold recoverable from all sources

Year	Bullion and precipitates recoverable (troy ounces)		Gold recoverable from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting[1]	Placers
1972	3,999	792,364	0.3	54.6	44.2	0.9
1973	15,381	583,311	1.3	49.6	48.1	1.0
1974	11,749	618,137	1.0	54.9	43.0	1.1
1975	13,783	617,330	1.3	58.7	38.1	1.9
1976	18,207	587,540	1.7	56.1	39.6	2.6

[1]Crude ores and concentrates.

Table 9.—Gold production at placer mines in the United States, by method of recovery

Method and year	Mines producing	Washing plants	Material washed (thousand cubic yards)	Gold recoverable: Thousand troy ounces	Gold recoverable: Value (thousands)	Gold recoverable: Average value per cubic yard
Bucketline dredging:						
1974	2	2	[1]656	5	$877	$1.336
1975	4	5	[1,2]2,715	14	2,314	.852
1976	3	4	[1,2]2,816	17	2,124	.754
Dragline dredging:						
1974	1	1	13	1	131	9.984
1975	6	6	210	3	469	2.229
1976	3	3	245	5	606	2.474
Hydraulicking:						
1974	16	16	223	2	381	1.710
1975	16	17	131	1	171	1.302
1976	14	14	129	1	157	1.212
Nonfloating washing plants:						
1974	14	14	[2]2	[3]3	461	[4]3.000
1975	11	11	([2])	[3]2	269	([4])
1976	25	26	[2]136	[3]4	560	[4]2.097
Underground placer, small-scale mechanical and hand methods, and suction dredge:						
1974	10	5	105	1	126	1.203
1975	12	8	27	([5])	47	1.752
1976	4	4	2	([5])	15	8.881
Total placers:						
1974	43	38	[1,2]999	[3]12	1,976	[4]1.523
1975	49	47	[1,2]3,083	[3]20	[6]3,269	[4].973
1976	49	51	[1,2]3,328	[3]28	3,462	[4]1.040

[1]Does not include platinum-bearing material from which byproduct gold was recovered.
[2]Excludes tonnage of material treated at commercial sand and gravel operations recovering byproduct gold.
[3]Includes gold recovered at commercial sand and gravel operations recovering byproduct gold.
[4]Gold recovered as a byproduct at sand and gravel operations not used in calculating average value per cubic yard.
[5]Less than 1/2 unit.
[6]Data do not add to total shown because of independent rounding.

Table 10.—U.S. refinery production of gold

(Thousand troy ounces)

<table>
<tr><th>Source</th><th>1972</th><th>1973</th><th>1974</th><th>1975</th><th>1976</th></tr>
<tr><td>Concentrates and ores:[1]</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Domestic</td><td>1,478</td><td>1,210</td><td>1,021</td><td>1,093</td><td>954</td></tr>
<tr><td>Foreign</td><td>125</td><td>112</td><td>185</td><td>250</td><td>123</td></tr>
<tr><td>Old scrap</td><td rowspan="2">2,107</td><td rowspan="2">1,779</td><td rowspan="2">1,926</td><td>1,122</td><td>1,068</td></tr>
<tr><td>New scrap</td><td>1,574</td><td>1,436</td></tr>
<tr><td>Total</td><td>3,710</td><td>3,101</td><td>3,132</td><td>4,039</td><td>3,581</td></tr>
</table>

[1]Includes other primary sources.

Source: 1972-74, Office of Domestic Gold and Silver Operations, U.S. Department of the Treasury; 1975-76, Bureau of Mines, U.S. Department of the Interior.

Table 11.—U.S. consumption of gold by end use

(Thousand troy ounces)

End use[1]	1972	1973	1974	1975	1976
Jewelry and arts:					
Karat gold	NA	NA	NA	1,747	2,153
Fine gold for electroplating	NA	NA	NA	31	29
Gold filled and other	NA	NA	NA	302	380
Total	4,344	3,473	2,402	2,080	2,562
Dental, total	750	679	509	595	694
Industrial:					
Karat gold	NA	NA	NA	39	56
Fine gold for electroplating	NA	NA	NA	[2]592	686
Gold filled and other	NA	NA	NA	428	491
Total	2,191	2,577	1,740	1,059	1,233
Investment[3]	--	--	--	258	159
Total consumption	7,285	6,729	4,651	[4]3,993	4,648

NA Not available.
[1]As reported by converters of refined gold.
[2]Figure as reported; however, 15% to 20% of this is estimated to go into jewelry as an end product.
[3]Fabricated bars, medallions, coins, and other products primarily for investment.
[4]Data do not add to total shown because of independent rounding.

Source: 1972-74, Office of Domestic Gold and Silver Operations, U.S. Department of the Treasury; 1975-76, Bureau of Mines, U.S. Department of the Interior.

Table 12.—U.S. exports of gold in 1976, by country

Destination	Ore, base bullion, and scrap		Refined bullion	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
Belgium-Luxembourg	134,976	$17,197	--	--
Brazil	25,023	2,343	59,825	$8,736
Canada	6,647	786	190,499	23,015
Germany, West	10,553	1,382	112,500	13,757
Guatemala	476	57	--	--
Hong Kong	7	1	18,994	2,208
Italy	--	--	3,372	393
Japan	35,792	4,222	24,556	2,849
Mexico	--	--	95,504	12,030
Netherlands	--	--	161	20
Paraguay	--	--	64	7
Poland	--	--	33,405	1,411
Spain	1,195	155	--	--
Sweden	2,780	345	--	--
Switzerland	6,808	875	1,188,383	90,348
United Kingdom	111,332	13,981	1,464,786	178,497
Venezuela	1,928	280	1,199	153
Total	337,517	41,624	3,193,248	333,424

Table 13.—U.S. imports (general) of gold in 1976, by country

Country	Ore, base bullion, and scrap		Refined bullion	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
Argentina	--	--	115,534	$14,170
Australia	11,126	$1,435	572	70
Bahamas	4	1	--	--
Brazil	--	--	592	75
Canada	43,620	5,305	1,556,962	194,361
Chile	4	([1])	2,411	301
Colombia	519	62	--	--
Dominican Republic	984	70	--	--
El Salvador	88	5	--	--

See footnotes at end of table.

Table 13.—U.S. imports (general) of gold in 1976, by country —Continued

Country	Ore, base bullion, and scrap		Refined bullion	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
France	283	36	49,897	5,978
Germany, West	--	--	32	4
Honduras	1,091	135	165	21
Hong Kong	4,214	541	6	1
Hungary	--	--	81	10
Italy	73	7	1,030	156
Japan	624	78	95,966	12,102
Korea, Republic of	2,265	241	--	--
Lebanon	4	1	--	--
Malaysia	5,956	747	--	--
Mexico	3,570	468	180	20
Netherlands	--	--	2,275	261
Netherlands Antilles	4	1	--	--
Nicaragua	17,297	2,112	87	11
Norway	627	97	--	--
Panama	478	57	280	38
Papua New Guinea	6,496	829	--	--
Paraguay	--	--	12,295	1,578
Peru	6,641	861	11,758	1,395
Philippines	40,231	5,099	--	--
Singapore	7,963	996	--	--
South Africa, Republic of	--	--	10,781	1,447
South-West Africa, Territory of	164	24	--	--
Switzerland	5	1	379,781	48,733
Taiwan	111	13	--	--
U.S.S.R.	33	4	96,501	11,280
United Kingdom	5,154	662	48,368	5,946
Uruguay	--	--	5,984	785
Venezuela	6,683	119	2,030	324
Yugoslavia	--	--	96,111	11,944
Total	166,312	20,007	2,489,679	311,011

[1]Less than 1/2 unit.

Table 14.—Value of gold exported from and imported into the United States

(Thousand dollars)

Year	Exports	Imports
1974	228,480	396,680
1975	492,932	456,638
1976	375,048	331,018

Table 15.—Gold: World production,[1] by country

(Troy ounces)

Country[2]	1974	1975	1976[p]
North America:			
Canada	1,698,392	1,653,611	1,685,983
Costa Rica	18,000	[e]18,000	[e]9,600
Dominican Republic	--	195,488	413,788
El Salvador[3]	6,022	8,713	3,007
Honduras	2,124	2,520	2,280
Mexico	134,454	144,710	162,811
Nicaragua	82,639	70,281	75,855
Panama	11	NA	NA
United States	1,126,886	1,052,252	1,048,037

See footnotes at end of table.

Table 15.—Gold: World production,[1] by country —Continued

(Troy ounces)

Country[2]	1974	1975	1976[p]
South America:			
Argentina	6,534	11,867	[e]12,000
Bolivia	[r]43,272	53,218	28,797
Brazil	188,435	172,038	183,259
Chile[3]	118,829	130,651	129,143
Colombia	265,195	308,864	297,861
Ecuador	7,752	8,157	11,615
French Guiana	1,125	2,443	2,797
Guyana	12,200	18,067	15,651
Peru	[r]100,400	78,796	80,730
Surinam	[r]406	141	39
Venezuela	[r]16,966	18,326	14,500
Europe:			
Finland	20,737	22,216	26,299
France	40,542	47,004	50,991
Germany, West	1,315	2,116	[e]2,250
Hungary[e]	320	300	290
Portugal	11,478	11,446	10,036
Romania[e]	60,000	60,000	60,000
Spain	[r]223,351	124,584	[e]270,000
Sweden	68,352	63,176	[e]73,900
U.S.S.R.[e]	7,300,000	7,500,000	7,700,000
Yugoslavia	170,302	177,922	[e]176,800
Africa:			
Angola	2,000	[e]1,000	[e]1,000
Burundi	360	368	426
Cameroon[3]	64	96	[e]100
Central African Empire[e]	64	529	400
Congo	707	528	482
Ethiopia	15,754	19,981	30,000
Gabon	7,298	4,207	3,086
Ghana[3]	[r]614,007	523,889	532,473
Kenya	[r]214	108	33
Liberia	[r] [e]3,000	4,500	[e]4,500
Mali[e]	[r]30	[r]30	3,500
Malagasy Republic	77	158	[e]160
Mauritania	[e]52,000	[e]42,000	22,120
Nigeria	[r]6	8	[e]10
Rhodesia, Southern[e]	800,000	800,000	800,000
Rwanda[3]	643	425	936
South Africa, Republic of	24,388,203	22,937,820	22,935,988
Sudan	309	[e]300	[e]300
Tanzania[4]	[r]71	48	10
Zaire[3]	130,603	103,217	102,882
Zambia[5]	[r] [e]8,500	[r] [e]8,500	10,955
Asia:			
Cambodia[e]	4,000	500	1,000
China, People's Republic of[e]	50,000	50,000	50,000
India[4]	101,114	90,826	100,696
Indonesia	76,491	74,954	82,781
Japan[6]	[r]139,719	143,503	137,669
Korea, North[e]	160,000	160,000	160,000
Korea, Republic of[4]	23,792	13,343	18,744
Malaysia:			
Malaya	[r]3,435	2,484	3,574
Sarawak	[r]1,004	1,192	964
Philippines[3]	[r]537,615	501,793	501,197
Taiwan	[r]22,850	22,110	26,952
Oceania:			
Australia	[r]512,611	526,821	497,693
British Solomon Islands	873	804	6,000
Fiji	68,890	68,744	65,757
New Zealand[3]	4,710	2,747	3,276
Papua New Guinea[7]	[r]667,237	611,356	668,142
Total	[r]40,124,290	38,675,796	39,322,125

[e]Estimate. [p]Preliminary. [r]Revised. NA Not available.

[1]Unless otherwise indicated, production is on the basis of mine output.

[2]Gold is also produced in Bulgaria and Czechoslovakia, and probably small quanties in Burma, East Germany, Guinea, Thailand and several other countries. However, available data are insufficient to make reliable output estimates. Data are lacking on clandestine activities.

[3]Figures are reported as fine gold (that is, almost pure).

[4]Figures are reported as refined metal.

[5]Estimated level of output for all producers, chiefly contained in blister copper and refinery muds. Previously reported figures at lower level did not represent total national output.

[6]Refinery production for Japan was as follows: 1974—[r]1,123,489 ounces; 1975—[r]1,036,004 ounces; 1976—1,043,676 ounces.

[7]Bougainville Copper Ltd. produced the following amounts as a byproduct of copper mining: 1974—[r]658,575 ounces; 1975—[r]584,307 ounces; 1976—650,151 ounces. In addition, other mining operations produced: 1974—8,662 ounces; 1975—27,049 ounces; 1976—578,423 ounces.

Graphite

By W. Thomas Cocke[1]

Natural graphite remained in tight supply in 1976 as the economy strengthened. Domestic consumption increased 10% according to a canvass of major consumers. Domestic production increased appreciably over that of 1975. Although some known graphite deposits were investigated, there were no new mine openings and only one mine remained in operation. National stockpile goals were increased to 3-year totals, which precluded the sale of material previously declared excess.

Imports of natural graphite increased 21%. A 28% increase in imports of amorphous graphite compensated for a 5% decrease in imports of crystalline graphite. Total exports increased 16%. Prices of imported material increased 5% for crystalline and 26% for amorphous in 1976. Domestic prices generally follow those of imported materials.

World production of graphite increased in 1976, with nearly all producers showing some increase. While supplies of amorphous graphite were adequate, premium grades of crystalline remained tight. Substitutes of lower grade materials appear to be successful.

Production of manufactured graphite increased 3% over that of 1975, owing primarily to a 17% increase in production of electrodes. Production was still well below the 1974 high.

Legislation and Government Programs.—On October 1, 1976, the Federal Preparedness Agency of the General Services Administration increased national stockpile goals to reflect an increase in requirements of strategic materials to a 3-year period. New stockpile objectives for each type of graphite are shown in table 2. There were no disposals of strategic graphite, declared excess prior to October 1, owing to lack of congressional authorization. Careful consideration will be given to market conditions before any aquisitions will be made to reach the new goals. Import duties on crystalline graphite remained suspended for a trial period in order to stimulate imports.

[1]Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient natural graphite statistics

	1972	1973	1974	1975	1976
United States:					
Consumption[e] [1] ______ short tons__	70,000	79,000	94,867	70,000	67,000
Exports ______ do____	7,289	7,953	12,189	10,586	12,236
Value ______ thousands__	$888	$992	$1,693	$1,890	$2,388
Imports for consumption[2] ______ short tons__	64,135	77,431	82,636	65,663	79,098
Value ______ thousands__	$3,847	$4,494	$5,677	$5,698	$6,753
World: Production ______ short tons__	397,894	435,150	[r]548,284	[r]486,025	499,995

[e]Estimate. [r]Revised.
[1]Estimated demand has been substituted for the consumption survey results appearing as the total of table 4, since the latter are incomplete.
[2]Includes some manufactured graphite.

DOMESTIC PRODUCTION

In 1976, natural graphite production was from a single source, the Southwestern Graphite Co. mine near Burnet, Tex. Shipments from the mine were higher than in 1975 but continued to account for only a small portion of domestic supply. Other graphite deposits in Alabama, New York, Montana, and the Province of Saskatchewan, Canada, received attention from investigators contemplating the development or redevelopment of additional mines, however, no mine openings occurred by yearend.

International Carbon and Minerals Corp. purchased mineral rights to 2,135 acres in the Alabama flake graphite district and plans to build a modern flotation plant with startup scheduled for mid-1977.[2]

Deep Bay Graphite Co. Ltd., a subsidiary of Superior Graphite Co. of Chicago, Ill., and the Saskatchewan Mining Corp. agreed to proceed with a feasibility study of a graphite mine near Reindeer Lake in northern Saskatchewan. Production of 9,000 tons of flake graphite per year is projected. Results of the study are expected late in 1977.[3]

Reported production of manufactured graphite increased 3% to 286,326 short tons. Total value of production increased 21% to $375 million. The overall increase in production was due to large increases in electrodes (17%), crucibles and vessels (32%), and motor brushes and machined shapes (64%). All other uses of manufactured graphite decreased 28%. Shipments of powder and scrap again decreased to 23,991 tons valued at $3.5 million, which indicated a doubling of value from $64 per ton in 1975 to $146 per ton in 1976. Production of high-modulus graphite fibers decreased, but a study conducted by R. M. Kossoff and Associates of New York showed manufactured graphite fibers and composites poised for a major volume breakthrough in the next decade.[4] Prices have declined from $200 per pound to about $30 per pound in 1976 and are expected to be in the $10 per pound range by the early 1980's. According to the study, 1976 consumption of manufactured graphite fibers was 260,000 pounds. This showed that demand for these fibers used in composites is two and a half times the annual production.

Manufactured graphite was produced at 24 plants in 1976, with some additional production for in-house use likely. The following is a list of principal producers in 1976:

Company	Plant location
Airco, Inc., Speer Div	Niagara Falls, N.Y.
Do	Punxsutawney, Pa.
Do	St. Marys, Pa.
Avco Corp., Avco Systems Div.	Lowell, Mass.
The Carborundum Co., Graphite Products Div.	Hickman, Ky.
Do	Sanborn, N.Y.
Celanese Corp., Celanese Research Lab.	Summit, N.J.
Fiber Materials, Inc	Graniteville, Mass.
Great Lakes Carbon Corp	Rosamond, Calif.
Do	Niagara Falls, N.Y.
Do	Morganton, N.C.
Hercules, Inc	Bacchus, Utah.
HITCO	Gardena, Calif.
Ohio Carbon Co	Cleveland, Ohio
Pfizer, Inc., Minerals Pigments & Metals Div.	Easton, Pa.
Poco Graphite, Inc	Decatur, Tex.
Polycarbon, Inc	North Hollywood, Calif.
Stackpole Carbon Co	Lowell, Mass.
Do	St. Marys, Pa.
Super Temp Co	Santa Fe Springs, Calif.
Union Carbide Corp	Niagara Falls, N.Y.
Do	Yabucoa, P.R.
Do	Columbia, Tenn.
Do	Clarksburg, W. Va.

Airco, Inc., Speer Div. completed expansion programs at plants in Pennsylvania and Niagara Falls, N.Y., which will enlarge production capacity at these facilities 20%.[5] The Carbon Products Division of Union Carbide Corp. has broken ground for a new graphite electrode plant at Clarksville, Tenn.[6] A plant capable of producing 11,000 tons per year of synthetic graphite and desulfurized petroleum coke was being constructed in Hopkinsville, Ky., by Superior Graphite Co.[7]

[2]Engineering and Mining Journal. V. 177, No. 2, February 1976, p. 125.

[3]Skillings' Mining Review. Major Graphite Discovery in Canada. V. 65, No. 48, Nov. 27, 1976, p. 8.

[4]Chemical Age. Graphite Fibers Are Set for a Major Volume Breakthrough by 1985, Says Recent Survey. Jan. 21, 1977, p. 4.

[5]Ceramic Industry. Airco Speer Expands Manufacturing 20%. V. 106, No. 3, March 1976, p. 20.

[6]American Metal Market. V. 82, No. 236, Dec. 7, 1976, p. 3.

[7]Skillings' Mining Review. Superior Graphite To Produce Desulfurized Petroleum Coke. V. 65, No. 22, May 29, 1976, p. 17.

Table 2.—Government yearend stocks of natural graphite

(Short tons)

Type of graphite	National stockpile (Dec. 31, 1976)	New objective (Oct. 1, 1976)
Malagasy crystalline flake	17,939	20,472
Sri Lanka amorphous lump	5,499	6,271
Crystalline, other than Malagasy and Sri Lanka	1,933	34,798
Non-stockpile-grade	867	--

Source: General Services Administration. Stockpile Report to the Congress, October 1976-March 1977.

Table 3.—Production of manufactured graphite in the United States in 1976, by use

Use	Quantity (short tons)	Value (thousands)
Synthetic graphite products:		
Anodes	25,176	$23,683
Electrodes	206,512	267,559
Crucibles and vessels	5,372	31,699
Refractories	1,912	1,961
Electric motor brushes and machined shapes	1,016	3,300
Unmachined graphite shapes	12,093	12,225
Cloth and fibers (low-modulus)	163	11,376
High-modulus fibers	49	4,965
Other	10,042	14,738
Total	262,335	371,506
Synthetic graphite powder and scrap	23,991	3,511
Grand total	286,326	375,017

CONSUMPTION AND USES

Reported consumption of natural graphite in 1976 increased 10% to 59,300 short tons. Consumption increased in all categories except steelmaking, which was stable, and foundries, which declined 22%. The three major uses, steelmaking, refractories, and foundries, accounted for 63% of reported consumption.

The actual amount of natural graphite consumed was greater than that shown in table 4, which reports only the results of a canvass of major known consumers. Total graphite consumption is estimated to have been 67,000 short tons in 1976.

Figure 1 summarizes graphite end use patterns as indicated by a canvass of major consumers. While the canvass probably gives a good indication of consumption patterns, caution is advised in use of these data for absolute amounts, due to the fact that the canvass in some years accounted for less than two-thirds of apparent consumption. Also, some major variations from year to year in various end uses may not be real because of inconsistencies in reporting.

Recent new or proposed uses for graphite-epoxy composites include the speedbrake for the McDonnell F-15 Air Force fighter to replace aluminum alloy;[8] 10% of the total structural weight of the McDonnell and Northrop F-18 Navy fighter;[9] upper aft rudders on DC-10's and payload bay doors on the space shuttle;[10] automobile leaf springs and drive shafts for weight reduction;[11] and machine tool parts for drastic reductions in weight.[12]

[8]Materials Engineering. Composite Speedbrake Slows Fighter. V. 83, No. 2, February 1976, p. 60.

[9]Yaeger, D. Composite Material Use in Jet Fighters Grows at McDonnell-Aircraft. Am. Metal Market, v. 83, No. 150, Aug. 2, 1976, p. 27.

[10]Iron Age. It's Time For a Change in Aircraft Materials. V. 217, No. 13, Mar. 29, 1976, pp. 33-38.

[11]Plastic Product Design, 1976 Newsletter for Materials Engineers and Product Designers. P. 2.

[12]Materials Engineering. Graphite-Epoxy Cuts Weight of Tool. V. 84, No. 3, September 1976, p. 68.

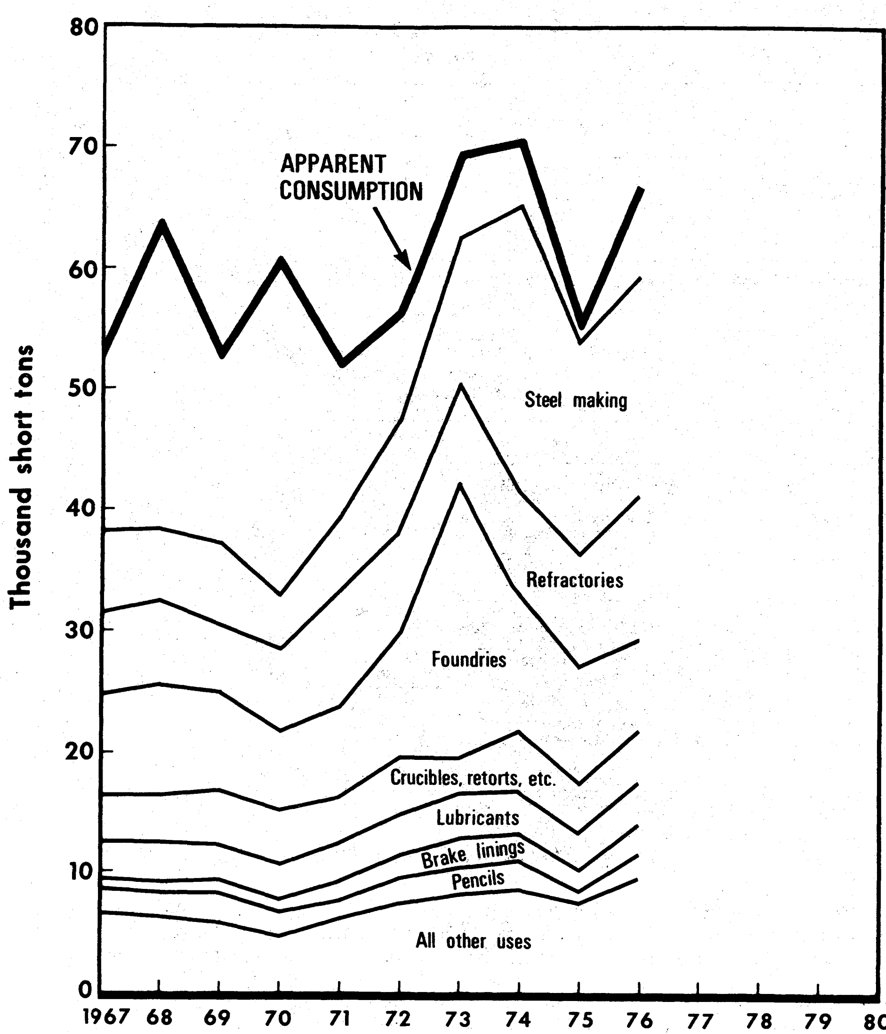

Figure 1.—Graphite end use patterns, 1967-76.

Table 4.—Consumption[1] of natural graphite in the United States in 1976, by use

(Short tons)

Use	Crystalline		Amorphous[2]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Batteries	394	$619,249	743	$518,843	1,137	$1,138,092
Brake linings	684	438,795	1,653	651,398	2,337	1,090,193
Carbon products[3]	796	518,040	974	719,311	1,770	1,237,351
Crucibles, retorts, stoppers, sleeves, nozzles	3,209	1,203,135	1,235	514,170	4,444	1,717,305
Foundries	1,729	670,297	5,821	883,566	7,550	1,553,863
Lubricants[4]	1,361	976,870	2,177	792,717	3,538	1,769,587
Pencils	1,652	1,033,654	520	134,131	2,172	1,167,785
Powdered metals	422	423,110	130	138,417	552	561,527
Refractories	1,987	322,325	9,897	1,197,181	11,884	1,519,506
Rubber	W	W	W	W	511	259,834
Steelmaking	470	206,563	17,306	3,032,538	17,776	3,239,101
Other[5]	5,567	1,496,247	573	315,177	5,629	1,551,590
Total	18,271	7,908,285	41,029	8,897,449	59,300	16,805,734

W Withheld to avoid disclosing individual company confidential data; included with "Other Crystalline" and "Other Amorphous."

[1]Consumption data incomplete. Small consumers excluded.

[2]Includes mixtures of natural and manufactured graphite.

[3]Includes bearings and carbon brushes.

[4]Includes ammunition, packings, and seed coating.

[5]Includes paints and polishes, antiknock and other compounds, drilling mud, electrical and electronic products, insulation, magnetic tape, small packages, and miscellaneous and proprietary uses.

PRICES

Average prices of graphite imports continued to increase in 1976 as worldwide inflation continued. The average price of Malagasy crystalline flake and fines increased about 4%, Sri Lanka amorphous lump and chip increased about 25% and Mexican amorphous increased about 5%. Decreases in prices occurred in imports of Norwegian and West German crystalline and Korean amorphous.

Actual prices are often negotiated between the buyer and seller, so price quotations represent the average of a range of prices. The source of information for imported graphite is the average value per ton computed from table 6; however, these data mainly represent shipments of unprocessed graphite.

The following tabulation[13] shows representative price ranges for several countries from which natural graphite is imported.

	Per short ton	
	1975[r]	1976
Flake and crystalline graphite, bags:		
Germany, West	$227-$907	$272-$1,270
Malagasy Republic	200-680	136-680
Norway	145-236	150-236
Sri Lanka	225-405	163-405
Amorphous, nonflake, cryptocrystalline graphite (80% to 85% carbon):		
Korea, Republic of (bags)	36	36
Mexico (bulk)	33	44-50

[r]Revised.

FOREIGN TRADE

The broad upward trend in exports of natural graphite continued in 1976, after a slight setback in 1975. Exports increased 16% in 1976 to 12,236 short tons. Canada remained the principal buyer with 3,394 tons. Other major recipient countries were West Germany (1,638 tons), Poland (1,127 tons), and Japan (1,062 tons). Graphite was also exported to 41 other countries.

Imports of natural graphite increased 21% to 77,698 short tons in 1976 but were still below the 1974 high of 81,070. A 28% increase in imports of amorphous graphite, due mostly to the 13,007 tons from the Republic of Korea, brought the amorphous portion to 83% of all imports. This is part of a gradual change over the last 25 years which has resulted in a shift from 65% amorphous in 1950 and 1951. Imports of crystalline graphite were 5% lower than in 1975, however, imports of crystalline flake from the Malagasy Republic increased 10% to 4,071 short tons, or roughly a third of all crystalline imports.

[13]Engineering and Mining Journal. Markets. V. 177, No. 12, December 1976, p. 48.

Table 5.—U.S. exports of natural graphite,[1] by country

Destination	1975 Quantity (short tons)	1975 Value	1976 Quantity (short tons)	1976 Value
Angola	51	$16,000	--	--
Argentina	116	24,545	197	$45,553
Australia	362	45,736	514	77,824
Austria	--	--	6	4,394
Belgium-Luxembourg	35	3,534	35	6,533
Brazil	235	32,337	137	44,861
Canada	2,707	596,820	3,394	773,893
Chile	--	--	11	4,685
Colombia	50	18,093	198	69,104
Denmark	104	29,304	76	10,941
Finland	50	4,906	26	3,243
France	231	35,183	435	122,829
Germany, West	1,638	216,373	1,638	326,999
India	99	11,276	41	5,316
Indonesia	6	1,148	--	--
Iran	70	19,126	17	6,250
Ireland	--	--	62	9,382
Israel	137	16,274	24	4,576
Italy	164	18,247	28	3,166
Japan	700	124,185	1,062	159,286
Korea, Republic of	--	--	68	8,230
Malaysia	--	--	10	1,099
Mexico	298	73,522	451	65,269
Netherlands	1,350	276,568	500	78,293
New Zealand	84	8,923	72	9,784
Norway	--	--	8	1,109
Panama	37	3,862	--	--
Paraguay	54	6,650	--	--
Peru	34	10,373	48	9,346
Philippines	249	31,755	105	34,621
Poland	18	2,000	1,127	154,921
Singapore	1	526	29	13,020
South Africa, Republic of	96	11,270	181	19,373
Spain	348	33,715	352	34,114
Sweden	61	8,453	97	11,229
Switzerland	33	3,370	33	6,462
Taiwan	34	3,659	--	--
Thailand	--	--	37	4,131
United Kingdom	804	92,775	649	84,819
Venezuela	280	94,467	449	154,768
Other	[r]50	14,743	119	19,023
Total	10,586	1,889,718	12,236	2,388,446

[r]Revised.
[1]Amorphous, crystalline flake, lump or chip, and natural, not elsewhere classified.

Table 6.—U.S. imports for consumption of natural and artificial graphite, by country

Year and country	Natural: Crystalline flake Quantity (short tons)	Natural: Crystalline flake Value (thousands)	Natural: Crystalline lump, chip or dust Quantity (short tons)	Natural: Crystalline lump, chip or dust Value (thousands)	Natural: Other natural crude and refined Quantity (short tons)	Natural: Other natural crude and refined Value (thousands)	Artificial[1] Quantity (short tons)	Artificial[1] Value (thousands)	Total Quantity (short tons)	Total Value (thousands)
1974	4,740	$1,003	382	$119	75,948	$4,254	1,566	$301	82,636	$5,677
1975:										
Belgium-Luxembourg	(2)	(2)	--	--	--	--	--	--	(2)	(2)
Brazil	2	1	--	--	--	--	--	--	2	1
Canada	247	75	32	19	51	13	1,241	144	1,571	251
China, People's Republic of	--	--	--	--	2,500	792	--	--	2,500	792
France	--	--	--	--	6	9	--	--	6	9
Germany, West	139	89	--	--	899	345	13	26	1,051	460
Hong Kong	--	--	--	--	20	7	--	--	20	7
Indonesia	183	44	--	--	67	12	--	--	250	56
Italy	--	--	--	--	(2)	2	--	--	(2)	2
Japan	--	--	--	--	11	2	39	107	50	109
Malagasy Republic	3,698	908	--	--	271	66	--	--	3,969	974
Mexico	--	--	--	--	50,283	1,488	--	--	50,283	1,488

See footnotes at end of table.

Table 6.—U.S. imports for consumption of natural and artificial graphite, by country —Continued

Year and country	Natural						Artificial[1]		Total	
	Crystalline flake		Crystalline lump, chip or dust		Other natural crude and refined					
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1975 —Continued:										
Netherlands	--	--	--	--	3	$1	--	--	3	$1
Norway	--	--	--	--	1,321	326	--	--	1,321	326
Sri Lanka	1	$1	218	$69	2,017	590	--	--	2,236	660
Switzerland	--	--	--	--	--	--	80	$63	80	63
Taiwan	--	--	--	--	(2)	(2)	--	--	(2)	(2)
U.S.S.R	--	--	--	--	2,280	475	--	--	2,280	475
United Kingdom	--	--	(2)	3	41	21	(2)	(2)	41	24
Total	4,270	1,118	250	91	59,770	4,149	1,373	340	65,663	5,698
1976:										
Austria	--	--	--	--	132	25	--	--	132	25
Canada	--	--	--	--	44	26	434	60	478	86
China, People's Republic of	120	32	--	--	2,479	669	55	19	2,654	720
France	--	--	10	3	61	27	1	1	72	31
Germany, West	259	125	--	--	1,180	399	317	89	1,756	613
India	--	--	--	--	17	15	--	--	17	15
Italy	--	--	5	7	--	--	(2)	1	5	8
Japan	--	--	20	7	60	21	354	135	434	163
Korea, Republic of	--	--	--	--	13,007	803	--	--	13,007	803
Malagasy Republic	4,071	1,053	11	3	664	153	--	--	4,746	1,209
Mexico	--	--	--	--	51,398	1,600	--	--	51,398	1,600
Norway	143	35	--	--	411	73	--	--	554	108
Panama	--	--	--	--	221	190	--	--	221	190
Sri Lanka	57	14	255	104	1,444	528	--	--	1,756	646
Switzerland	--	--	--	--	20	15	239	188	259	203
Thailand	--	--	--	--	57	20	--	--	57	20
United Kingdom	37	13	--	--	71	15	--	--	108	28
U.S.S.R	--	--	--	--	1,360	263	--	--	1,360	263
Vietnam	--	--	84	22	--	--	--	--	84	22
Total	4,687	1,272	385	146	72,626	4,842	1,400	493	79,098	6,753

[1]Includes only that received in raw material form; excludes products made of graphite.
[2]Less than 1/2 unit.

WORLD REVIEW

World production of graphite increased slightly in 1976, with nearly all producers showing some increase. Mexico and the Republic of Korea remained the main producers of amorphous graphite. Shortages of Malagasy flake graphite have lessened, but industry continued to seek viable alternative sources.

Brazil.—A growing producer, Brazil has a current annual capacity of 8,000 tons per year of flake and powdered graphite at the principal deposits in Itapecerica.[14] This could develop into an important source of flake graphite.

Canada.—An intensive drilling and bulk sampling program is underway at a graphite deposit in the Deep Bay area near Reindeer Lake in Saskatchewan. Quality tests must be conducted before a decision is made to proceed with commercial production.[15] Deep Bay Graphite Co. Ltd., a subsidiary of Superior Graphite Co., owns a 60% interest, with Saskatchewan Mining Corp. holding the remaining 40% interest in the graphite mine. Open pit reserves are estimated to be 1.8 million tons containing 10.32% carbon. Production of 9,000 tons per year of flake graphite is projected. About 9 tons of product is being produced at a pilot plant at Lakefield Research of Canada, Ltd., to be distributed to industry for assessment in industrial processes and market acceptance. Results of the feasibility study are expected in late 1977.[16]

[14]Industrial Minerals. Natural Graphite Retains Traditional Markets. No. 109, October 1976, p. 27.
[15]Department of Mineral Resources, Government of Saskatchewan. Inventory and Outlook of Saskatchewan's Mineral Resources. April 1976, p. 35.
[16]Work cited in footnote 3.

Germany, West.—Production of crystalline flake graphite is by one company, Graphitwerk Kropfmuhl, which has embarked on a new investment program involving the installation of underground machinery at the mine, as well as new milling and flotation equipment.[17]

Korea, Republic of.—Production of amorphous graphite dropped 15% while production of crystalline was up 50% from 1975 and up nearly 300% in the last 2 years.[18] Korean amorphous has become a replacement for imported materials from Mexico, which have dropped off in recent years.

Malagasy Republic.—Establissements Gallois, the largest of the country's graphite producers, recently brought its new deposit into operation. Other producers also have made significant plant improvements. The island industry should be in better condition to meet increased demand.[19] French owners would reportedly sell out to the Government if reasonable terms were offered. There is still the distinct possibility of nationalization in a negotiated settlement or otherwise.[20]

Mexico.—This country can be described as a mature mining area with good deposits increasingly more difficult to locate. Output has leveled off in recent years, despite efforts to increase production.[21] Production has actually been dropping since 1973, the peak year.

Norway.—A/Skaland Grafitverk continued work on the deep shaft at mines in the Lofoten Islands, Troms County, preparatory to extraction of graphite deposits from below sea level. Improvements to surface installations include new screening equipment.[22] Development work at the mine is continuing, and further graphite grades have been produced in response to increased demands for powder fractions and larger flake grades.[23] Norway continued to be a stable and readily available source of graphite.

Sri Lanka.—Development work proceeded satisfactorily at all three principal graphite mines at Bogala, Kahatagaha, and Kolongaha along with the development of the new mine at Rangala. The State Graphite Corp., which works these mines, is installing a flotation plant for the upgrading of the ore.[24] A mine at Walakatahena, closed following a disaster in the 1930's, is of being

[17]Work cited in footnote 7.
[18]Mining Annual Review-1977. The Republic of Korea. June 1977, pp. 398-399.
[19]Cooper, H. T. Graphite. Mining Annual Review-1976, June 1976, p. 119.
[20]U.S. Embassy, Tananarive, Malagasy Republic. State Department Airgram A-031, May 4, 1976, p. 5.
[21]Page 25 of work cited in footnote 7.
[22]Work cited in footnote 15.
[23]Cooper, H. T. Graphite. Mining Annual Review-1977, June 1977, p. 119.
[24]Mining Annual Review-1976. Sri Lanka. June 1976, p. 407.

Table 7.—Graphite: World production, by country

(Short tons)

Country[1]	1974	1975	1976[p]
Argentina	[r]66	44	[e]45
Austria	32,573	33,715	[e]35,800
Brazil (marketable)	6,111	7,275	[e]7,700
Burma	[2]336	96	110
China, People's Republic of[e]	[r]45,000	55,000	55,000
Germany, West[3]	18,172	14,944	[e]15,500
India	25,420	20,824	[e]22,000
Italy	[r]2,601	1,431	[e]1,700
Korea, North[e]	85,000	85,000	85,000
Korea, Republic of	115,589	52,064	[e]55,000
Malagasy Republic	19,049	19,592	[e]20,000
Mexico	68,951	67,036	[e]68,000
Norway	[r]10,690	10,334	[e]10,500
Romania[e]	6,600	6,600	6,600
Sri Lanka	[4]10,414	11,493	[e]11,600
South Africa, Republic of	1,712	577	[e]440
U.S.S.R.[e]	[r]100,000	[r]100,000	105,000
United States	W	W	W
Total	[r]548,284	486,025	499,995

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]In addition to the countries listed, Czechoslovakia, Southern Rhodesia, and the Territory of South-West Africa are believed to produce graphite, but available information is inadequate for formulation of reliable estimates of output levels.
[2]Data for year Apr. 1, 1974, through Mar. 31, 1975.
[3]Data represent marketable production, including some produced from imported raw materials.
[4]Exports.

reclaimed. Substantial resources have been allotted to research and development for the first time in the industry's history. Equipment has been manufactured for the production of flake graphite by the sieve-rolling process, and new flotation equipment has been installed at Bogala.[25] Work also commenced on a prospective mine at Ragedera, where mining was to commence at the end of 1977.[26]

TECHNOLOGY

Graphite intercalants have been the subject of several investigations owing to their ability to modify the properties of various compounds. Graphite intercalated compounds have shown high electrical conductivity.[27] Pure graphite powder, treated with antimony pentafluoride as an intercalant, is packed into a copper tube, and the diameter is reduced by swaging from 0.25 to 0.04 inch. The resulting rod shows electrical conductivity up to 50% higher than the copper alone, owing to alinement of the intercalant layers and orientation of the graphite. Graphite intercalants might be used as electrical wire, as this process also imparts high strength, light-weight, and elasticity.[28] In a related study, electrical charge is applied through a nonaqueous lithium perchlorate solution to an electrode formed of powdered graphite and lithium fluoride.[29] The resulting electrochemically formed graphite intercalation compound is suitable for reversible positive electrodes for storage battery systems utilizing electrolytic solutions of nonaqueous lithium compounds. The formation of graphite intercalated compounds with certain reagents is a simple way to modify their reactivity. Stoichiometric reactions and electrolytic reactions were studied for intercalation of organic and inorganic molecules. More work is suggested to standardize preparation of reagents and for reuse of graphite.[30]

Direct fluorination of graphite produces carbon monofluoride, which has outstanding oxidative and thermal properties, excellent dielectric properties, and is a superior lubricant.[31] Studies continue; preparation appears to be the main problem.

New graphite products include a mold-release coat used as a release for no-bake sand cores and as an aluminum extrusion lubricant,[32] and a graphite-base adhesive which allows repair and restoration of glass-to-metal seal fixtures for use at temperatures of up to 4,500° C.[33] High-alumina compositions containing graphite are used to formulate the most successful pouring nozzles for high-manganese steel.[34] Graphite heat exchangers can now operate at temperatures up to 1,200° C, aided by a new glassy-carbon coating which seals pores to minimize shrinking. Phenolic-resin-coated units have been limited by the coating to about 340° F.[35]

Graphite substrate lead dioxide anodes have been developed with sizes suitable for use in high-amperage cells involved in producing chlorates and perchlorates.[36] Electrodeposited lead dioxide shows the promise of developing high efficiency as an inert and insoluble anode. It is the only present alternative to platinum for producing perchlorates.

The hot-pressing process used to shape flat and curved boron carbide armor plate consists of preforming the boron carbide grains and then subjecting them to simultaneous high temperature and pressure in graphite molds.[37] Graphite is the only known material that can withstand the heat (4,000° F) and pressure needed to densify the material and fuse the boron carbide grains. Graphite is also easily machinable into intricate configurations,

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[25]Page 22 of work cited in footnote 7.

[26]Mining Annual Review-1977. Sri Lanka. June 1977, p. 408.

[27]Gan, J. N., and F. L. Vogel, Jr. Preferred Orientation and Anisotropy of Graphite Intercalation Compounds. Electro-chemical Division, University of Pennsylvania, Philadelphia, Pa., July 12, 1976, 33 pp.

[28]Chemical and Engineering News. V. 54, No. 14, Apr. 5, 1976, p. 14.

[29]Hebbar, R. K., D. L. Deshpande, and P. N. Critchlow. Electrochemical Formation of Graphite Intercalation Compounds for Storage Batteries. Office of Naval Research, (Arlington, Va.), Ser. No. 567,923, May 12, 1975, 19 pp.; available from National Technical Information Service, Springfield, Va. AD-D002864.

[30]ChemTech. V. 6, No. 8, August 1976, pp. 510-515.

[31]Page 529 of work cited in footnote 21.

[32]Metal Progress. V. 110, No. 8, December 1976, p. 81.

[33]Materials Engineering. V. 84, No. 7, December 1976, p. 71.

[34]Hallet, M. M., IBF 1976 Conference-Part II. Foundry Management and Technology, v. 104, No. 11, November 1976, p. 30-31.

[35]Chemical Engineering. V. 83, No. 21, Oct. 11, 1976, p. 65.

[36]Narasimham, K. C., and H. V. K. Udupa. Preparation and Applications of Graphite Substrate Lead Dioxide (GSLD) Anode. J. Electrochem. Soc., v. 123, No. 9, September 1976, pp. 1294-1298.

[37]Iron Age. Advanced Ceramics Compete for Industrial Jobs. V. 217, No. 18, May 3, 1976, pp. 51-53.

such as the reverse airfoil shapes required for turbine blade and vane molding, which are hot-pressed from silicon nitride and silicon carbide powders.

Graphite is the most widely used of all electrical discharge machine (EDM) materials.[38] It is very machinable, relatively low in cost, and exhibits good thermal and electrical conductivity. A copper-impregnated graphite of high density (2.6 grams per cubic centimeter) with fine grain structure permits machining of EDM materials to fine detail. While low-density graphite electrodes cost less, they wear more rapidly and unevenly, resulting in unacceptable tolerances.

Research and development continued as interest in production items of carbon and graphite fibers increased. Components fabricated of silicon-carbide-processed graphite composites can withstand temperatures of 3,250° F in reducing or inert atmospheres.[39] They also feature excellent wear and abrasion resistance. Uses include pump seals, bearings, and soldering fixtures.

Pultrusion, the process of pulling resin-impregnated fibers through shaped dies, can achieve the kind of cost effectiveness necessary for composites to get a wider foothold in industrial applications.[40] Composites made from graphite fibers created by this process are used in the manufacture of a variety of components for textile equipment, leisure products, and aerospace parts.

Some of the problems encountered in use of graphite-epoxy composites are moisture absorption and promotion of galvanic corrosion when the composites are placed in contact with certain metals.[41] Moisture absorption is the most serious problem because it can greatly affect flexural, compressive, and shear strength of the matrix. Potential methods of preventing moisture absorption include ion vapor deposition of aluminum and use of a high-vinyl modified epoxy or a new class of addition-polymerized polyaromatic melamines as the matrix. Galvanic corrosion of aluminum rivets presents a serious risk in composites. The use of chromate conversion coatings over cadmium plate or the use of titanium or A-286 superalloy fasteners could prevent this hazard.

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[38]McMahon, D. R. Graphite Most Widely Used, All Purpose EDM Material. Am. Metal Market, v. 83, No. 56, Mar. 22, 1976, p. 26.

[39]Materials Engineering. Silicon-Carbide/Graphite Composites. V. 84, No. 7, December 1976, p. 53.

[40]Iron Age. Pultrusion Makes Composites Cost-Effective. V. 217, No. 19, May 10, 1976, pp. 58-59.

[41]Miska, K. H. Corrosion of Advanced Composites: A Problem With Solutions. Materials Eng., v. 84, No. 7, December 1976, pp. 46-48.

Gypsum

By J. W. Pressler[1]

In 1976, the gypsum industry recovered from the recession in the building industries in 1975. Output of crude gypsum increased 23% to 12 million tons. Production of calcined gypsum increased 20% to 11 million tons. Sales of gypsum products increased 16% to 18 million tons. Imports of crude gypsum increased 14% to 6.2 million tons. Total value of gypsum products sold increased 27% to $655 million.

Table 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Active mines and plants[1]	108	112	116	110	117
Crude:					
Mined	12,328	13,558	11,999	9,751	11,980
Value	$48,504	$56,650	$52,894	$44,654	$59,888
Imports for consumption	7,718	7,661	7,424	5,448	6,231
Byproduct gypsum sales	279	322	463	369	573
Calcined:					
Produced	12,005	12,592	10,993	9,181	11,036
Value	$195,862	$205,326	$205,713	$186,478	$236,775
Products sold (value)	$560,569	$632,809	$623,102	$513,617	$654,860
Exports (value)	$5,276	$7,360	$10,844	$10,481	$32,594
Imports for consumption (value)	$22,042	$21,937	$21,889	$19,810	$21,754
World: Production	64,470	67,829	r67,704	r62,855	66,231

rRevised.
[1]Each mine, calcining plant, or combination mine and plant is counted as one establishment.

DOMESTIC PRODUCTION

The United States was the world's leading producer of gypsum, accounting for 18% of the total world output.

Thirty-nine companies mined crude gypsum at 68 mines in 22 States. Output increased 23% but was 12% below the 1973 record. Leading producing States were Michigan, California, Texas, Iowa, and Oklahoma. These five States each produced more than 1 million tons and together accounted for 64% of the total domestic production. Stocks of crude ore at mines at yearend were 2.1 million tons.

Leading companies were United States Gypsum Co. (13 mines), National Gypsum Co. and Georgia-Pacific Corp. (6 mines each), Celotex Div. of Jim Walter Corp. (4 mines), The Flintkote Co. (3 mines), and H. M. Holloway Inc. (1 mine). These 6 companies, operating 33 mines, produced 79% of the total crude gypsum.

Leading individual mines were National Gypsum's Tawas mine in Iosco County, Mich.; United States Gypsum's Plaster City mine in Imperial County, Calif.; United States Gypsum's Alabaster mine in Iosco County, Mich.; H. M. Holloway's Lost Hills mine in Kern County, Calif.; and United States Gypsum's Southard mine in Blaine County, Okla. These five mines accounted for 27% of the national total. Average output per mine for the 68 U.S. mines was

[1]Physical scientist, Division of Nonmetallic Minerals.

176,000 tons, compared with 143,000 tons per mine in 1975 and 160,000 tons in 1974.

Thirteen companies calcined gypsum at 72 plants in 29 States. Output increased 20%, but was 12% below the 1973 record. Leading States were California, Texas, Iowa, and New York. These 4 States, with 24 plants, accounted for 39% of the national total.

Leading companies were United States Gypsum Co. (23 plants), National Gypsum Co. (18 plants), Georgia-Pacific Corp. (9 plants), The Flintkote Co. (6 plants), and Celotex Div. of Jim Walter Corp. (5 plants). These 5 companies, operating 61 plants, accounted for 87% of the national total.

Leading individual plants were United States Gypsum's Plaster City plant, Imperial County, Calif.; United States Gypsum's Shoals plant, Martin County, Ind.; Georgia-Pacific's Acme plant, Hardeman County, Tex.; United States Gypsum's Southard plant, Blaine County, Okla.; United States Gypsum's Oakfield plant, Genesee County, N.Y.; United States Gypsum's Fort Dodge plant, Webster County, Iowa; and Weyerhaeuser's Briar plant, Howard County, Ark. These seven plants accounted for 21% of the national total. Average output per plant for the 72 U.S. plants was 155,000 tons, compared with 124,000 tons per plant in 1975 and 145,000 tons in 1974.

Occidental Petroleum Corp., Valley Nitrogen Producers Inc., Collier Carbon & Chemical Corp., and California Industrial Minerals Co., (all in California); Occidental Petroleum Corp. in Florida; Miles Laboratories, Inc., in Indiana; and Texasgulf Inc., in North Carolina, sold 573,300 tons of byproduct gypsum valued at $4.2 million for agricultural purposes.

During 1976, National Gypsum Co. had a golden anniversary at its National City plant and Tawas quarry in Iosco County, Mich., having started initial operations in 1926. The quarry now produces about 600,000 tons of crude gypsum per year, and the plant produces about 500,000 square feet of wallboard per day. Some of the crude gypsum is sold to the cement industry for use as a set-retardant, and the unused balance is shipped to the company's other plants in the Great Lakes area.[2]

Only one gypsumboard plant was started up during the year, while three small plants were shut down, with no gain or loss in national production capacity. American Gypsum Co.'s Albuquerque plant in Bernadillo County, N. Mex., started operations in the last quarter of 1976. Its associated White Mesa gypsum mine in Sandoval County, N. Mex., was the source of the crude gypsum feed. Three board plants were closed in 1976: Kaiser Cement & Gypsum Corp.'s Delanco plant, Burlington County, N.J.; United States Gypsum Co.'s New Brighton plant, Richmond County, N.Y.; and Temple Industries' Dallas plant, Dallas, Tex. The Locust Cove underground gypsum mine of United States Gypsum Co., Smyth County, Va., was also closed.

The Gypsum Association announced on January 3, 1977, that the available capacity of operating gypsumboard plants in the United States as of yearend 1976 was 16.5 billion square feet per year. These data were obtained from a complete survey of the industry conducted with the cooperation of the Bureau of Mines.[3] Total 1976 gypsumboard production in the United States was 13.1 billion square feet. This indicated a 79.5% national utilization of capacity for the year.

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[2]Bay City Times, Bay City, Mich. Iosco National Gypsum Plant in Production for 50 Years, Aug. 22, 1976, sec. A. p. 10.

[3]Letter to the Gypsum Association. Peat, Marwick, Mitchell & Co. Feb. 8, 1977; available for consultation at the Bureau of Mines, Washington, D.C.

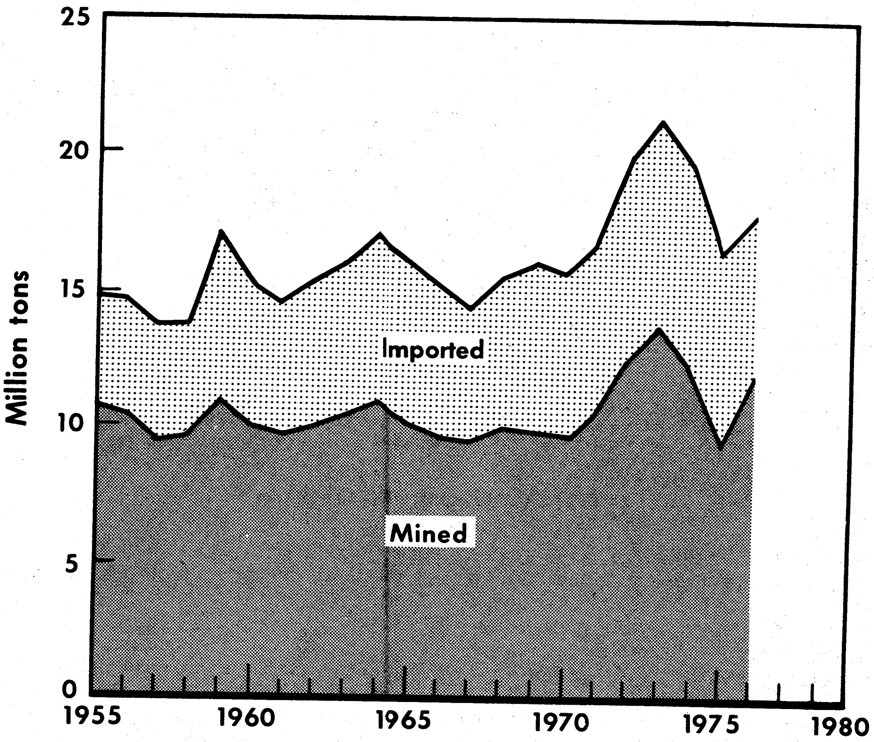

Figure 1.—Supply of crude gypsum in the United States.

Table 2.—Crude gypsum mined in the United States, by State

(Thousand short tons and thousand dollars)

State	1975			1976		
	Active mines	Quantity	Value	Active mines	Quantity	Value
Arizona	4	117	419	4	139	529
California	4	1,446	6,332	4	1,647	7,897
Colorado	4	185	782	5	215	984
Iowa	6	1,208	6,546	6	1,486	8,288
Michigan	5	1,224	5,936	5	1,837	9,842
Nevada	4	558	2,375	4	792	3,884
Oklahoma	7	1,028	4,835	7	1,120	5,822
South Dakota	1	23	60	W	W	W
Texas	7	1,094	4,277	7	1,531	6,322
Utah	5	247	1,457	5	270	1,657
Wyoming	3	271	902	3	317	1,280
Other States[1]	18	2,350	10,733	18	2,626	13,383
Total	68	9,751	44,654	68	11,980	59,888

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1]Includes Arkansas, Idaho, Indiana, Kansas, Louisiana, Montana, New Mexico, New York, Ohio, South Dakota (1976), Virginia, and Washington.

Table 3.—Calcined gypsum produced in the United States, by State

(Thousand short tons and thousand dollars)

State	1975 Active plants	1975 Quantity	1975 Value	1976 Active plants	1976 Quantity	1976 Value
California	7	1,035	15,849	7	1,476	21,481
Florida	3	344	7,038	3	378	7,359
Georgia	3	512	11,225	3	548	13,181
Iowa	5	851	17,802	5	1,003	20,823
Michigan	4	385	9,689	4	456	13,924
Nevada	3	319	6,148	3	495	10,005
New Jersey	4	433	5,254	3	400	6,316
New York	6	716	13,494	6	740	15,139
Ohio	3	339	5,180	3	396	7,839
Texas	7	842	19,428	6	1,094	26,934
Other States[1]	29	3,405	75,371	29	4,051	93,774
Total	74	9,181	186,478	72	[2]11,036	236,775

[1]Includes Arizona, Arkansas, Colorado, Delaware, Illinois, Indiana, Kansas, Louisiana, Maryland, Massachusetts, Montana, New Hampshire, New Mexico, Oklahoma, Pennsylvania, Utah, Virginia, Washington, and Wyoming.

[2]Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Apparent consumption of crude gypsum (production plus imports, minus exports) increased 19% to 17.9 million tons. Imports provided 35% of the crude gypsum consumed. Apparent consumption of calcined gypsum increased 20% to 11.0 million tons.

Stocks of crude gypsum at mines and calcining plants at yearend were 2.1 million tons. Of this, 1.2 million tons (55%) was at calcining plants in coastal States.

Of the total gypsum products sold or used, 5.4 million tons (30%) was uncalcined. Of the total uncalcined gypsum, 3.4 million tons (64%) was used for portland cement, and 1.7 million tons (32%) was used in agriculture. The leading sales regions for gypsum used in cement were the West North-Central, West South-Central, and Pacific; these three regions accounted for 46% of the total. For agricultural gypsum, the Pacific sales region accounted for 86% of the total.

Of the total calcined gypsum, 94% was used for prefabricated products and 6% for industrial and building plasters. Of the prefabricated products, 80% was regular wallboard, 12% was fire-resistant Type X wallboard, and only 1% was lath. Of the regular wallboard, 84% was 1/2 inch and 9% was 3/8 inch. The leading sales regions for prefabricated products were the Pacific, East North-Central, and South Atlantic; these three regions accounted for 48% of the total. For plasters, the East North-Central, Middle Atlantic, and South Atlantic regions accounted for 59% of the total.

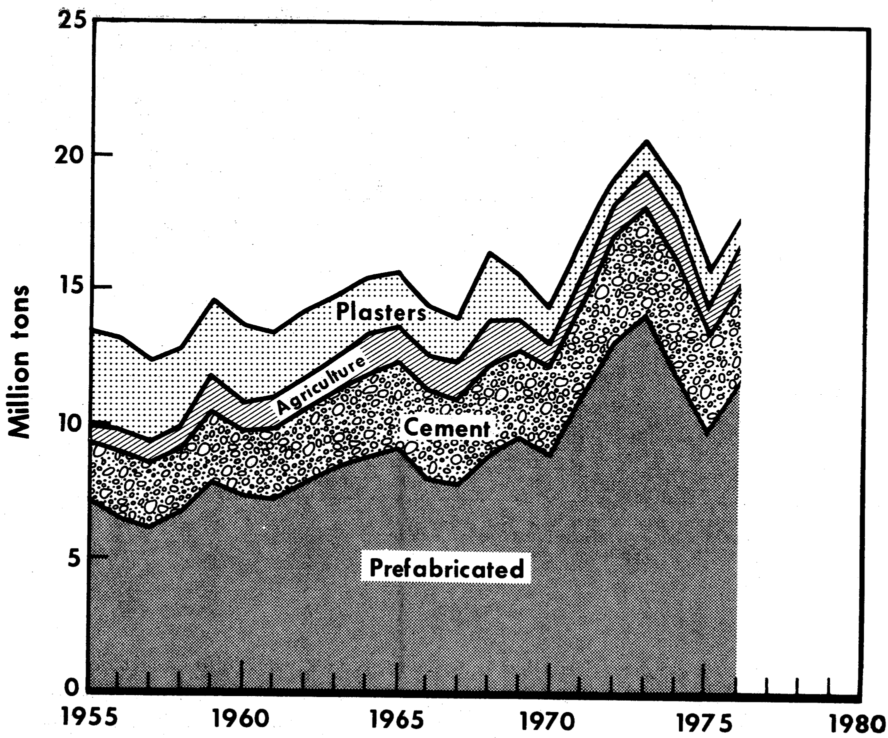

Figure 2.—Sales of gypsum products, by use.

Table 4.—Gypsum products (made from domestic, imported, and byproduct gypsum) sold or used in the United States, by use

(Thousand short tons and thousand dollars)

Use	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Uncalcined:				
Portland cement	3,244	21,341	3,417	24,908
Agriculture[1]	1,482	9,138	1,714	12,229
Other	178	2,588	244	3,662
Total	4,904	33,067	5,375	40,799
Calcined:				
Industrial plaster	294	14,847	306	16,556
Building plaster:				
Regular base coat	176	6,120	155	6,193
Mill-mixed base coat	125	5,356	128	6,056
Veneer plaster	73	4,907	86	6,270
Other[2]	162	6,232	121	5,362
Total	[3]535	22,615	490	23,881
Prefabricated products[4]	9,855	443,089	11,849	573,624
Total calcined	10,684	[3]480,550	12,645	614,061
Grand total	15,588	513,617	18,020	654,860

[1]Includes 369,000 tons of byproduct gypsum in 1975 and 573,300 tons in 1976.
[2]Includes gaging, molding, and Keene's cement, roof deck concrete, and other uses.
[3]Data do not add to total shown because of independent rounding.
[4]Includes weight of paper, metal, or other materials.

Table 5.—Prefabricated products sold or used in the United States, by product

Product	1975			1976		
	Thousand square feet	Thousand short tons[1]	Value (thousands)	Thousand square feet	Thousand short tons[1]	Value (thousands)
Lath:						
3/8-inch	171,922	135	$7,144	173,437	135	$7,461
1/2-inch	9,142	8	397	9,267	8	430
Total[2]	181,064	143	7,541	182,704	144	7,892
Veneer base	292,188	278	12,975	362,981	345	16,677
Sheathing	199,340	189	9,098	272,567	254	12,818
Regular gypsumboard:						
3/8-inch	926,841	736	24,027	983,762	757	39,124
1/2-inch	6,952,283	6,171	267,140	8,766,838	7,747	352,634
5/8-inch	490,594	465	24,919	561,503	530	28,951
1 inch	15,978	31	1,935	17,068	32	2,085
Other[3]	129,774	103	5,177	164,737	118	7,032
Total[2]	8,515,470	7,507	323,197	10,493,908	9,183	429,826
Type X gypsumboard	1,408,512	1,600	70,655	1,593,577	1,737	80,717
Predecorated wallboard	135,462	130	17,749	194,549	171	22,974
Other	9,972	8	1,873	17,293	14	2,721
Grand total[2]	10,742,008	9,855	443,089	13,117,579	11,849	573,624

[1]Includes weight of paper, metal, or other material.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes 1/4-inch, 5/16-inch, and 3/4-inch gypsumboard.

ENERGY

More efficient production scheduling and a higher rate of operational capacity contributed to an increase in the energy efficiency of the gypsum industry in 1976, with a 10.8% improvement compared with the base year of 1972. British thermal unit consumption per thousand square feet of gypsumboard sales in 1976 was 2.76 million, compared with 2.97 million in 1975.[4]

As reported by the Gypsum Association, the percent fuel source for the gypsum industry in 1976 was as follows: Natural gas, 76.43%; electricity, 5.92%; coal, 2.91%; propane, 2.40%; No. 1 oil, 3.00%; No. 2 oil, 9.10%; and No. 6 oil, 0.24%.

PRICES

The average value of crude gypsum increased from $4.58 per ton in 1975 to $5.00 in 1976. The average value of calcined gypsum increased from $20.31 per ton in 1975 to $21.45 in 1976. The average value of byproduct gypsum sold decreased from $7.96 in 1975 to $7.36 per ton in 1976.

The average value of gypsum products sold or used increased from $32.95 in 1975 to $36.34 per ton in 1976. Prefabricated products were valued at $48.41 per ton, industrial plasters at $54.10 per ton, building plaster at $48.74, and uncalcined products at $7.59 per ton.

Quoted prices for gypsum are published monthly in Engineering News-Record. Prices at yearend showed a wide range, based on delivered prices. Regular 1/2-inch wallboard prices ranged from $44 per thousand square feet at Dallas to $93 at Chicago. Prices for building plaster ranged from $61 per ton at San Francisco to $96 at Denver.

FOREIGN TRADE

Increased exports of gypsumboard, panels, and tile were made to Canada and the U.S.S.R. Total value of gypsum product exports to all countries was $32.6 million, a sharp increase of 211% over 1975. The gypsum industry is import reliant. In 1976, 35% of the crude gypsum consumed was imported. Imports were from Canada (72%), Mexico (21%), Jamaica (6%), and the Dominican Republic and Brazil (the other 1%). Imports increased 14% to 6.2 million tons. Most of the imported crude gypsum was mined by subsidiaries of U.S. companies in Canada and Mexico.

[4]U.S. Department of Commerce and Federal Energy Administration. Voluntary Industrial Energy Conservation. An update of Progress Report No. 5, July 1977, pp. 90-91.

Table 6.—U.S. exports of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude, crushed, or calcined		Other manufactures n.e.c.	Total value
	Quantity	Value	Value	
1974	132	3,910	6,934	10,844
1975	75	4,505	5,976	10,481
1976	284	6,739	25,855	32,594

Table 7.—U.S. imports for consumption of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude		Ground or calcined		Alabaster manufactures[1]	Other manufactures n.e.c.	Total value
	Quantity	Value	Quantity	Value	Value	Value	
1974	7,424	17,602	2	107	1,976	2,204	21,889
1975	5,448	16,021	2	172	1,365	2,252	19,810
1976	6,231	18,061	22	224	1,572	1,897	21,754

[1]Includes imports of jet manufactures, which are believed to be negligible.

Table 8.—U.S. imports for consumption of crude gypsum, by country

(Thousand short tons and thousand dollars)

Country	1975		1976	
	Quantity	Value	Quantity	Value
Australia	--	--	(1)	(1)
Brazil	--	--	8	10
Canada	4,022	11,344	4,468	13,811
Dominican Republic	123	2,438	84	1,496
Italy	(1)	9	(1)	7
Jamaica	274	659	356	574
Mexico	1,027	1,567	1,315	2,163
United Kingdom	2	4	--	--
Total	5,448	16,021	6,231	18,061

[1]Less than 1/2 unit.

WORLD REVIEW

Domestic and foreign resources of gypsum are adequate for any foreseeable time. World reserves are conservatively estimated at 2 billion tons.

Brazil.—Rhône-Poulenc of Paris, France, announced that Sociedade Comercial e Industrial de Artefactos de Gesso (SCIAG), a Brazilian offshoot, will construct three plants for the conversion of phosphogypsum into materials useful in the construction industry. The first plant was to be built at Cajati where the phosphogypsum will be converted into semihydrate by a Rhône-Poulenc process, and used for the production of 110,000 tons per year of pellets for set-retarding of cement. A factory in São Paulo will also use the semihydrates to produce plaster tiles, using a Rhône-Poulenc patented process.[5]

[5]Chemical Age. SCIAG Goes Ahead With Phosphogypsum Plan. V. 114, No. 3000, Jan. 14, 1977, p. 6.

Canada.—Canada was the fourth leading producer of crude gypsum, accounting for 9% of the world total. About 80% of the gypsum mined in Canada is from the Atlantic Provinces, where quarries are operated by subsidiaries of U.S. gypsum companies and exported to the eastern seaboard of the United States to meet raw material requirements of the building industry.

Westroc Industries Ltd. announced a major expansion of its Ontario gypsum operations, including the development of a new mine in the township of Blandford-Blenheim in Oxford County, and a further increase in the capacity of its Mississauga gypsum wallboard plant. The $5 million underground mine development was initiated with the sinking of a 12-foot diameter by 400-foot deep vertical shaft. Scheduled commencement of operations was mid-1978. The deposit has at least 30 years of reserves.[6]

Anhydrite was produced in Canada by Fundy Gypsum Co. Ltd. at Westworth, Nova Scotia, and by Little Narrows Gypsum Co. Ltd. at Little Narrows, Nova Scotia. (Production and trade data on anhydrite are included with those for gypsum). Some 219,000 tons was mined in 1975 and shipped to the United States for use in portland cement manufacture and as a peanut crop fertilizer. In this latter use it is somewhat more effective on a theoretical basis, 100% compared with 79% available $CaSO_4$ in gypsum.[7]

France.—France was the third leading gypsum-producing country, with 10% of the world total.

India.—The discovery of deposits of high-grade gypsum in the States of Jammu and Kashmir, estimated at 110 million tons, was announced by the Geological Survey of India. Half of the deposits are located near Doda and the other half near Baramulla. Because of India's sulfur import dependence, a private Indian company, Orissa Cement Ltd. of Rajgangpur, Orissa, was seeking a joint venture for the production of sulfur from gypsum.[8]

Iran.—As a result of a survey conducted in 1975 and 1976, the Iranian Ministry of Mines and Industry announced the gypsum reserves of Iran to be 666 million tons of proven reserves and 1,373 million tons of probable reserves.[9]

Japan.—Japanese production of crude gypsum has been progressively reduced from 406,000 tons in 1973 to only 71,000 tons in 1976, and import-export trade was minimal in 1976. Japanese technology for the recycling of byproduct gypsum was leading the world. In 1975, a total of 5.5 million tons of chemical gypsum was produced as a byproduct of phosphoric acid production and other chemical processing such as sodium sulfite, sulfuric acid, sodium sulfate, and from 137 different thermal power plants with fluegas desulfurization systems.

Including a small amount of natural gypsum, 2.1 million tons of gypsum was used in 1975 as a set-retarder in the cement manufacturing industry, 1.4 million tons was used in the manufacture of wallboard, and 700 thousand tons was used for construction plaster and plaster of Paris. The average value of byproduct gypsum in 1976 was equivalent to $5.25 per ton. Even with this high degree of utilization, surplus byproduct gypsum was increasing, and it was becoming a problem to secure sites for storage and treatment. The Ceramic Society of Japan estimated there would be a vast oversupply of byproduct gypsum by 1980, with stocks in Japan totaling over 12 million tons despite an optimistic growth rate in the consumption level during this period.[10]

Mexico.—In 1976, Mexico produced 1.6 million tons of crude gypsum, most of which was exported to the United States. The remainder was used in the cement industry as a set-retardant and as the raw material supply for two small gypsumboard plants owned by subsidiaries of United States Gypsum Co. and Kaiser Cement & Gypsum Corp. The large amount exported came from San Marcos Island, in the Territory of Baja California Sur, and was produced by the Mexican subsidiary of Kaiser Cement & Gypsum Corp., Cia. Occidental Mexicana

[6]Canadian Mining Journal. December 1976, p. 57.

[7]Stonehouse, D. H. Gypsum and Anhydrite. Canadian Minerals Yearbook 1975, 8 pp.

[8]U.S. Embassy, New Delhi, India. State Department Telegram 5572, Apr. 25, 1977, pp. 1-2.

[9]U.S. Embassy, Teheran, Iran. State Department Airgram A-225, Apr. 22, 1977, pp. 1-2.

[10]Harbin, Peter. The Industrial Minerals of Japan (Part 2). Industrial Minerals, No. 119, August 1977, pp. 15-39.

Japanese Ministry of International Trade and Industry (Tokyo). Concerning the Promotion of Countermeasures for Calcium Sulphates, July 5, 1976, 11 pp.

S.A. This deposit has large reserves of high-quality gypsum ore and serves the West Coast of the United States. At yearend, the Mexicanization of the subsidiary was proceeding according to the plan of the Mexican Government requiring that 60% of the equity be sold to Mexican interests.[11]

Pakistan.—The gypsum reserves of Pakistan were announced as 74 million tons in 1976. Large deposits of gypsum have been found in different regions in Punjab, Sind, Baluchistan, and North-West Frontier Provinces, and were being used in the production of cement, chemical fertilizers, plaster of paris, etc. Production in 1976 was 488,000 tons and was mainly consumed by the fertilizer industry for neutralizing the effect of saline and alkaline soils.[12]

Romania.—Process Engineering Co. of France announced a contract to build a phosphogypsum processing plant at Bacau. The plant will convert residual phosphogypsum from acidulation of phosphate rock into plaster tiles for the Romanian construction industry. Output will be 110,000 tons per year, equivalent to 16 million square feet of tiles. The project will combine the Rhône-Poulenc expertise in the purification and firing of phosphogypsum and the Lambert Industries' experience in converting the material into finished products.[13]

South Africa, Republic of.—The Republic of South Africa's somewhat limited gypsum industry remained in a lethargic state throughout most of 1976, reflecting (for the second consecutive year) a slackened domestic market. Volume of local sales was off 6% compared with that of 1975. Price rises, the result of inflation, were of little help and did not present a favorable outlook for 1977. Indications were that gypsum consumed in the Republic of South Africa during 1976 declined to the level of 532,000 tons.[14]

Spain.—Production of gypsum in Spain has been quite constant since 1968, remaining between 4 and 5 million tons per year. In 1976, Spain retained its important position in world gypsum production, ranking fifth, with 7% of the total.

Spain has abundant and extensive deposits of gypsum that occur in most regions of the country. The principal areas of Spanish production are in Barcelona, Madrid, Toledo, Burgos, Castellon, Zaragoza, and Leon, and the main centers of consumption are in the large industrial areas, such as Catalonia and Madrid, and in the main tourist regions of the Mediterranean and the Balearic and Canary Islands. At least four of the larger companies are important, but very little domination of the industry was apparent. Exports have grown from about 4,000 tons in 1970 to 211,000 tons in 1974, principally to Scandinavian countries.[15]

Thailand.—Gypsum production in Thailand peaked at 344,000 tons in 1974 and has subsequently fallen to 281,000 tons in 1975, and 296,000 tons in 1976. This was largely due to the depressed state of both the domestic and overseas building industry. The bulk of the production is consumed in the local cement and gypsumboard industry. Most of the exports, which reached over 130,000 tons in 1974, went to Malaysia, Taiwan, and other Southeast Asian countries. Two Provinces had most of the production-Phichit with reserves of 25 million tons, and Nakhon Sawan with 10 million tons of reserves.[16]

U.S.S.R.—The U.S.S.R. produced 11% of the world's gypsum in 1976 and ranked second in total world production.

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[11]Kaiser Cement & Gypsum Corp. Annual Report, 1976, pp. 12, 14.
United States Gypsum Co. Annual Report, 1976, p. 15.
[12]U.S. Embassy, Islamabad, Pakistan. State Department Airgram A-069, June 22, 1977, p. 71 of enclosure.
[13]Chemical Age. PEC Wins Gypsum Contract in Romania. V. 113, No. 2994, Dec. 3, 1976, p. 7.
[14]U.S. Embassy, Johannesburg, South Africa. State Department Airgram A-10, Jan. 31, 1977, pp. 38-39 of enclosure 1.
[15]Industrial Minerals. No. 103, April 1976, p. 31.
[16]Industrial Minerals. No. 177, June 1977, p. 27.

Table 9.—Gypsum: World production, by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
North America:			
Canada[2,3]	7,964	6,304	6,240
Cuba[e]	94	94	94
Dominican Republic	[r][e]149	[4]162	140
El Salvador[e]	7	7	7
Guatemala	[e]14	14	15
Honduras	9	1	[e]1
Jamaica	296	260	309
Mexico	1,529	1,384	1,559
Nicaragua[e]	39	39	17
United States	11,999	9,751	11,980
South America:			
Argentina	366	563	[e]600
Bolivia[4]	4	1	[e]1
Brazil[5]	[r]466	425	[e]424
Chile	149	199	133
Colombia	[r]218	220	[e]220
Ecuador	[r]1	[e]1	[e]1
Paraguay	16	17	18
Peru	384	[e]386	[e]386
Venezuela	181	233	189
Europe:			
Austria[2]	886	849	730
Belgium[2]	113	244	242
Bulgaria	[r]317	[e]317	[e]317
Czechoslovakia	693	702	661
France[2]	6,906	6,409	6,449
Germany, East[e]	[r]718	712	717
Germany, West (marketable)	[r]2,538	2,297	[e]2,535
Greece	[r]487	459	452
Ireland	423	364	391
Italy[e]	3,858	3,858	3,858
Luxembourg	4	5	2
Poland[e,6]	1,220	1,320	1,390
Portugal	158	165	[e]176
Spain	[r]4,494	4,652	[e]4,629
Switzerland[e]	110	77	77
U.S.S.R.[e,6]	[r]6,600	[r]6,900	7,100
United Kingdom	[r]4,191	3,835	4,409
Yugoslavia	[r]358	413	604
Africa:			
Algeria	[r]53	[e]55	[e]55
Angola[e]	44	44	44
Egypt	[r]619	606	515
Ethiopia	2	--	--
Kenya[2]	[e]110	[e]110	86
Libya[e]	3	4	4
Mauritania	9	14	11
Niger	2	1	3
South Africa, Republic of	621	594	532
Sudan[2]	33	33	20
Tanzania	23	14	[e]15
Tunisia	[e]44	[e]55	43
Zambia	4	8	4
Asia:			
Burma[7]	[e]30	43	40
China, People's Republic of[e]	[r]990	880	1,100
Cyprus	28	45	65
India	1,183	893	784
Indonesia[e]	9	9	9
Iran[e]	2,600	[r]2,700	2,800
Iraq	--	171	--
Israel	220	220	220
Japan	368	206	71
Jordan	33	33	23
Korea, Republic of[e,6]	[r]700	[r]570	680
Lebanon	14	[e]14	[e]14
Mongolia[e]	39	39	39
Pakistan	213	309	488
Philippines	139	130	68
Saudi Arabia	19	[e]19	[e]19
Syrian Arab Republic[e]	17	17	27
Taiwan	4	3	3
Thailand	344	281	296
Turkey	42	42	36
Vietnam[e]	8	8	8
Oceania: Australia	1,178	1,046	[e]1,036
Total	[r]67,704	62,855	66,231

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Gypsum is also produced by Romania, but production data are not available.
[2]Includes anhydrite.
[3]Shipments.
[4]Net exports.
[5]Sum of crude mine production sold directly and output of salable beneficiated product.
[6]Includes byproduct gypsum.
[7]Burmese fiscal year runs from April 1 of the year stated.

TECHNOLOGY

The Norwegian firm of Den Norske Gipsplatefabrikk (DNG), has commissioned the first stage of a $6.7 million plant to produce polyurethane-filled plasterboard wall structures at Svelvik, near Drammen, Norway. The new plant is the first in the world to produce such wall structures by continuous production methods. The new system jointly uses DNG's experience in plasterboard manufacture and Imperial Chemical Industries Ltd.'s urethane foam expertise. Initial production capacity of the DNG plant will be about 5.4 million square feet per year of *Gipsotex Multielement.* An eightfold expansion is planned over the next 4 years.[17]

An investigation was conducted by the Construction Materials Group of Battelle Memorial Institute's Columbus Laboratories to study the suitability of phosphogypsum as a reaction-rate controlling additive to portland cement and for the production of gypsum wallboard. The research revealed the feasibility within the cement manufacturing and wallboard markets. Results of the project revealed that the use of processed gypsum in cement had no detrimental effect on the properties of fresh concrete, such as increased air content or increased water requirements. Satisfactory wallboard was produced, and processed gypsum-stucco appeared to be as good as that of commercial plaster. The primary chemical impurities in the processed gypsum (Fe_2O_3 and $CaCO_3$) were not viewed as deleterious from the manufacturing or product performance viewpoint.[18]

Imperial Chemical Industries Ltd.'s Agricultural division (Billingham, Cleveland, England) developed a continuous process for the conversion of byproduct gypsum to the α-hemihydrate in a wet slurry, thereby producing a feedstock acceptable in plaster and gypsumboard manufacturing. The principal process characteristic was a double autoclave system, in which a slurry of gypsum, containing crystal habit modifiers, was heated by direct steam injection to 150° C at a pressure of 100 pounds per square inch to convert it to α-hemihydrate.[19]

Tightened Environmental Protection Agency pollution control standards forced several titanium dioxide producers to adopt the sulfate process, thereby getting into the byproduct gypsum business. Output of gypsum was at least five times that of titania production and similar to the production of phosphogypsum byproduct from the acidulation of phosphate rock to produce phosphoric acid. The treatment plant of American Cyanamid Co. in Savannah, Ga., developed a two-stage neutralization of the strong acid effluent stream using pulverized limestone, and produced both a high-purity gypsum product and a high-iron, low-grade product.[20]

The application of gypsum or landplaster is very important in the fertilization of peanuts in the Southeastern States. Gypsum is a soil moderator, it promotes the more efficient use of balanced fertilizers, and it is an insurance factor against the formation of "pops" or unsound kernels during dry weather. Seed quality is influenced by the availability of gypsum; seeds with less than 500 parts per million of calcium germinate below desirable levels while those with more than 500 parts per million usually germinate well and produce vigorous seedlings.[21]

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[17]European Chemical News. V. 29, No. 748, Aug. 6, 1976, p. 11.

[18]Lankard, D. R., and W. A. Hedden. Industrial Applications for Processed Gypsum. Rock Products, v. 79, No. 6, June 1976, pp. 72-76.

[19]Allen, M. Conversion of Byproduct Gypsum to α-Hemihydrate by ICI's Process. Phosphorus & Potassium, No. 78, July/August 1975, pp. 42-44.

[20]Chemical Week. TiO_2 Plants Survive By Making Gypsum. V. 121, No. 1, July 6, 1977, p. 29.

[21]Perry, A. Farm Chemicals, v. 139, No. 10, October 1976, p. 62.

Helium

By Thomas G. Clarke[1]

Total domestic sales of high purity helium (minimum 99.995% purity) in 1976 decreased 3% to 580 million cubic feet compared with 601 million cubic feet in 1975.[2] Bureau of Mines sales constituted 31% of the total; private industry accounted for the remainder. High purity helium exports, all by private industry, increased about 21% to 174 million cubic feet from 144 million cubic feet in 1975. The Bureau of Mines f.o.b. plant price for high purity helium in 1976 was $35 per thousand cubic feet, unchanged since 1961. High purity helium sold by private producers averaged about $22 per thousand cubic feet, down from $24 per thousand cubic feet in 1975.

Suits filed against the Government in 1975 were pending in the U.S. Court of Claims at yearend 1976. The suits, seeking damages up to $273 million, contended that supply contracts under the Bureau of Mines conservation program were breached. Similarly, in June 1976, a third company filed suit and asked damages of $102 million.

DOMESTIC PRODUCTION

A total of 12 plants had the capacity to extract helium from natural gas during the year. Ten of the plants were owned by private industry, and the other two were owned by the U.S. Government and operated by the Bureau of Mines at Keyes, Okla., and Exell, Tex. Six extraction plants were located in Kansas, three in Texas, and one each in Arizona, New Mexico, and Oklahoma. Three private plants were not in operation at yearend 1976 (see table 2).

Total helium extracted from natural gas by both private and government sources was 1.34 billion cubic feet, an increase of 24% compared with that of 1975. Total high purity extraction increased about 1% compared with a 7% increase in 1975; crude helium extraction was 75% higher compared with an 81% increase in 1975. Of total helium extracted during the year, crude helium comprised 44% of the total; high purity helium for sale constituted 56%. The Bureau of Mines accounted for 33% of the crude helium and 24% of the high purity helium extracted, private industry accounted for the remainder.

Initial performance tests were conducted in January on a 35-liter-per-hour helium liquefier at the Amarillo shipping terminal. Tests indicated the unit performed near rated capacity. In April, the first liquid helium dewars were received to support the liquid helium distribution operations at the terminal.

Several potential energy-saving projects were initiated at the Keyes Plant during the year. These included the installation of orifice flowmeters to measure full gas usage to engine compressors; a water meter to provide information on excess water loss; fixtures to test injection valves; equipment to determine engine turbocharger efficiency; and a kilowatt-hour meter to determine incremental electrical usage within each plant operations area.

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[1]Mineral specialist (petroleum), Division of Petroleum and Natural Gas.

[2]All helium statistics in this chapter are in terms of contained helium measured at 14.7 pounds per square inch absolute at 70° F.

Table 1.—Helium extracted from natural gas in the United States

(Thousand cubic feet)

	1972	1973	1974	1975	1976[p]
Crude helium:[1]					
Extracted at Bureau of Mines plants	262,197	175,976	169,414	183,725	193,150
Extracted at private industry plants	3,204,806	2,381,971	15,073	149,794	391,553
Total	3,467,003	2,557,947	184,487	333,519	584,703
High purity helium:[2]					
Extracted at Bureau of Mines plants	173,526	180,114	168,662	184,524	180,285
Extracted at private industry plants	453,675	467,102	[3]530,312	[3]560,899	[3]574,087
Total	627,201	647,216	698,974	745,423	754,372
Grand total	4,094,204	3,205,163	883,461	1,078,942	1,339,075

[p]Preliminary.
[1]Excludes crude helium purified after interplant transfer.
[2]Includes only those quantities produced for sale; quantities entering conservation storage system after purification are included under crude helium.
[3]Includes helium purified at the Bureau of Mines Keyes plant for the account of others.

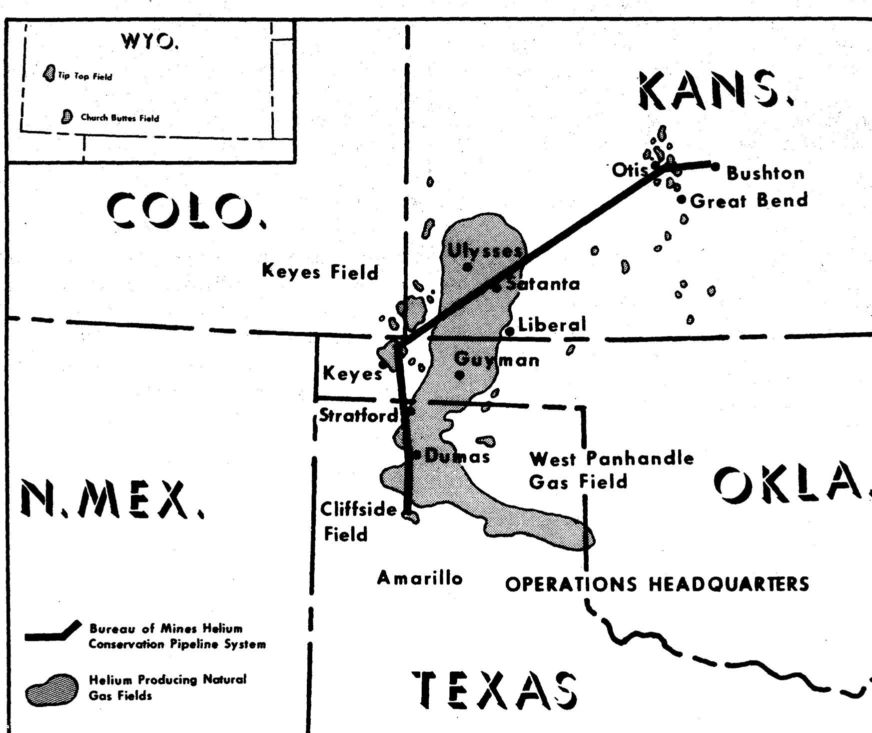

Figure 1.—Major U.S. helium-producing gasfields.

Table 2.—Ownership and location of helium extraction plants in the United States, 1976

Category and owner or operator	Location	Product purity
Government owned:		
Bureau of Mines	Exell, Tex	Crude helium.
Do	Keyes, Okla	Crude and high purity helium.
Private industry:		
Alamo Chemical-Gardner Cryogenics	Elkhart, Kans	High purity helium.
Cities Service Cryogenics, Inc	Scott City, Kans	Crude helium.[1]
Cities Service Helex, Inc	Ulysses, Kans	Crude and high purity helium.
Kansas Refined Helium Co	Otis, Kans	High purity helium.
Kerr-McGee Corp[2]	Navajo, Ariz	Do.
National Helium Corp[3]	Liberal, Kans	Crude helium.
Northern Helex Co	Bushton, Kans	Crude helium.[4]
Phillips Petroleum Co[5]	Dumas, Tex	Crude helium.
Do[6]	Hansford County, Tex	Do.
Western Helium Co	Redrock, N. Mex	High purity helium.

[1]Output is piped to Cities Service Helex, Inc., plant at Ulysses, Kans., for purification.
[2]This plant was closed permanently on Feb. 28, 1976 due to depletion of reservoir.
[3]This plant has not operated since late 1973 to early 1974.
[4]Output is being stored in the Bureau's Conservation System.
[5]This plant was shutdown in 1976. The helium-bearing gas supply contract for this plant expires on Oct. 29, 1977.
[6]This plant in operation in 1976, but at reduced capacity.

Table 3.—Summary of Bureau of Mines helium plant and Amarillo shipping terminal operations

(Thousand cubic feet)

	1974	1975	1976
Supply:			
Inventory at beginning of period [1]	8,632	9,291	9,805
Helium extracted:[2]			
Exell plant:			
Crude	35,036	36,111	12,443
Keyes plant:			
Crude	134,378	147,614	180,707
High purity[3]	170,194	186,399	181,574
Total Keyes plant	304,572	334,013	362,281
Total extracted	339,608	370,124	374,724
Helium returned in containers (net)	2,935	1,349	717
Total supply	351,175	380,764	385,246
Disposal:			
Sales of high purity helium	168,662	184,524	180,285
Net deliveries to helium conservation system[4]	173,222	186,435	196,580
Inventory at end of period[1]	9,291	9,805	8,381
Total disposal	351,175	380,764	385,246

[1]At Exell and Keyes plants and at Amarillo shipping terminal.
[2]Excludes conservation helium produced from native gas withdrawal wells at Cliffside field that have been invaded by stored helium.
[3]Excludes 28,657,000 cubic feet purified for others in 1974, 39,396,000 cubic feet in 1975, and 63,226,000 cubic feet in 1976.
[4]Excludes return of conservation helium produced as indicated in footnote 2 to conservation storage system.

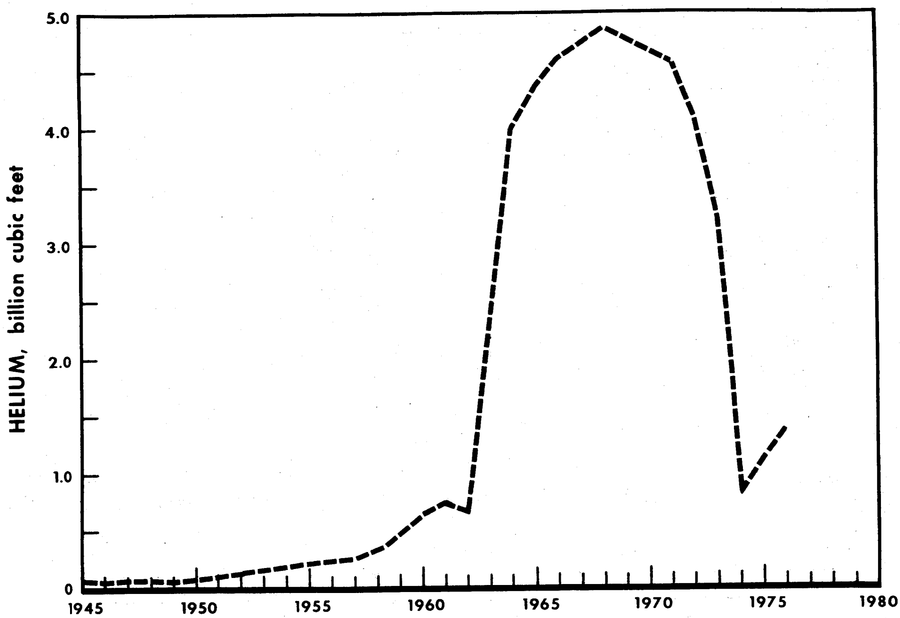

Figure 2.—Helium production in the United States, 1945-76.

CONSUMPTION AND USES

Principal domestic end uses of helium in 1976 were in welding, purging and pressurizing of rockets and spacecraft, research, and maintenance of controlled atmospheres. Other uses included lifting gas, leak detection, cryogenics, heat transfers, and synthetic breathing mixtures. Total domestic demand during the year was centered mainly in the Pacific and Gulf Coast States.

Federal agency purchases in the form of direct sales from the Bureau of Mines constituted about 54% of the Bureau's total high purity helium production. Almost all of the remaining sales of high purity helium by the Bureau were to Federal agencies through the General Services Administration contracts to private distributors, as required by law to purchase equivalent quantities from the Bureau. These contracts made relatively small quantities of helium readily available to Federal installations at reduced freight charges for small purchases.

The Bureau of Mines f.o.b. plant price of high purity helium in 1976 was $35 per thousand cubic feet, unchanged since 1961, and maintained for the purpose of financing the Government's helium conservation program. Except in special circumstances, this was not competitive with the private producer average price of $22 per thousand cubic feet, f.o.b. plant.

All high purity helium sold by the Bureau of Mines was shipped in gaseous form in cylinders, railroad tank cars, highway tanker trailers, and in liquid form in containerized dewars from the Amarillo shipping terminal. Private industry distributors shipped helium in both gaseous and liquid forms. Much of the helium transported in liquid form was delivered by semitrailer and/or containerized dewars to distribution centers where it was regasified and compressed into trailers and small cylinders for delivery to the end user.

Table 4.—Total sales of high purity helium in the United States

(Million cubic feet)

Year	Quantity
1972	[e]515
1973	[e]530
1974	[e]570
1975	601
1976	[p]580

[e]Estimate. [p]Preliminary.

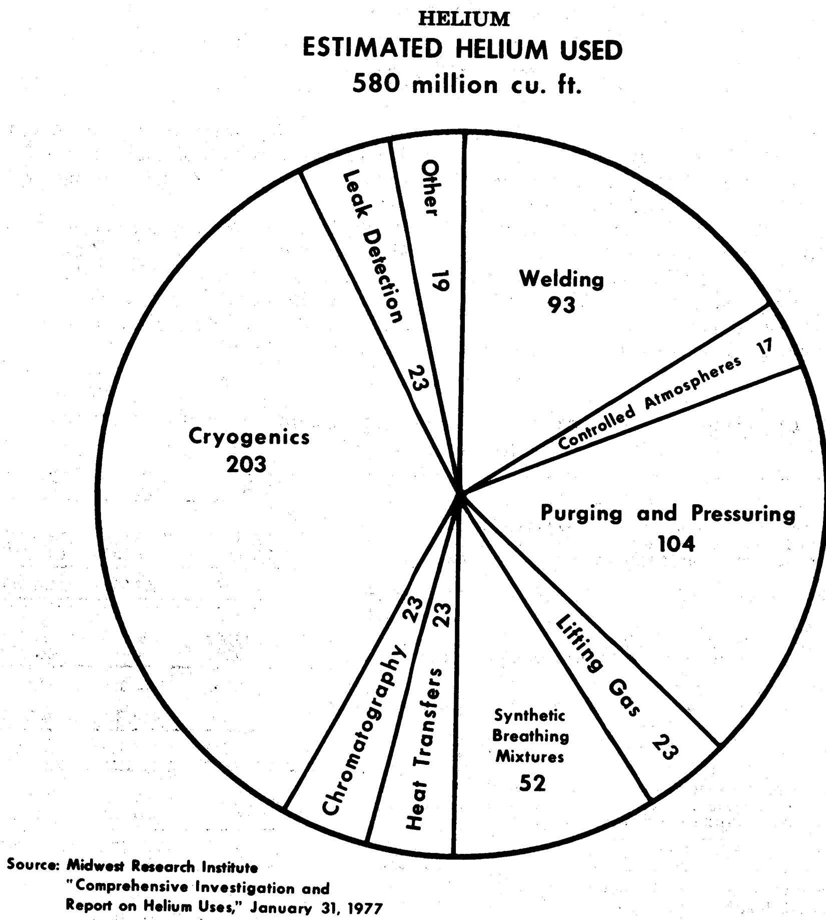

Figure 3.—Helium consumption by end use in the United States, 1976.

Table 5.—Bureau of Mines sales of high purity helium, by recipient

(Thousand cubic feet)

	1974	1975	1976[p]
Federal agencies:			
Atomic Energy Commission[1]	21,169	17,184	14,596
Department of Defense	45,432	60,551	67,827
National Aeronautics and Space Administration	13,684	21,046	8,884
National Weather Service	2,957	1,746	1,515
Other[2]	4,298	4,968	4,757
Total Federal agencies	87,540	105,495	97,579
Private helium distributor sales[3]	81,122 (combined with commercial sales)	77,049	80,185
Commercial sales		1,980	2,521
Grand total	168,662	184,524	180,285

[p]Preliminary.
[1]Became part of Energy Research and Development Administration on Jan. 19, 1975.
[2]Includes quantities used by the Bureau of Mines.
[3]Most of this was purchased by commercial firms which sold equivalent quantities to Federal installations under contract agreements with the General Services Administration.

CONSERVATION

Helium held in the Bureau of Mines conservation storage system, which includes the conservation pipeline network and the Cliffside gasfield near Amarillo, Tex. was 39,091 million cubic feet at yearend 1976, an increase of slightly over 1% from that in 1975. Helium stored under the conservation program was 37,666 million cubic feet, an increase of 1,967 million cubic feet during 1976. Private producers had a balance of 1,425 million cubic feet stored under contract with the Bureau in the conservation system (for future redelivery) at yearend 1976.

The conservation storage system contains crude helium purchased by the Bureau of Mines under contracts entered into with four companies in 1961 and continued under court orders obtained during 1971 by three of the companies.

Table 6.—Summary of Bureau of Mines helium conservation system[1] operations

(Thousand cubic feet)

	1974	1975	1976
Helium in conservation storage system at beginning of period:			
Stored under Bureau of Mines conservation program[2]	37,110,126	37,283,348	37,469,783
Stored under contract for private producers own accounts	1,091,004	995,987	1,087,587
Total	38,201,130	38,279,335	38,557,370
Input to system:			
Net deliveries from Bureau of Mines plants[3]	173,222	186,435	196,580
Stored under contract for private producers own accounts	15,073	200,131	583,133
Total	188,295	386,566	779,713
Redelivery of helium stored under contract for private producers own accounts	-110,090	-108,531	-245,789
Net addition to system	78,205	278,035	533,924
Helium in conservation storage system at end of period:			
Stored under Bureau of Mines conservation program[2]	37,283,348	37,469,783	37,666,363
Stored under contract for private producers own accounts	995,987	1,087,587	1,424,931
Total	38,279,335	38,557,370	39,091,294

[1]Includes conservation pipeline system and Cliffside field.
[2]Includes helium accepted after Apr. 14, 1973, under court order.
[3]Excludes return to system of conservation helium produced from native gas withdrawal wells at Cliffside field which have been invaded by stored helium.

Table 7.—Deliveries and withdrawals of crude helium stored for private companies' own account in the Bureau of Mines conservation storage system, 1976

(Thousand cubic feet)

Owner	Plant location	Delivered	Withdrawn	Net
Cities Service Helex, Inc	Ulysses, Kans	-253	3,870	-4,123
Northern Helex Co	Bushton, Kans	393,010	19,211	373,799
Phillips Petroleum Co	Dumas, Tex	--	16,481	-16,481
Jack B. Kelley Co	Bushton, Kans	--	26,328	-26,328
Kansas Refined Helium Co	do	190,376	172,623	17,753
Linde Division, Union Carbide Corp	do	--	7,276	-7,276
Total		583,133	245,789	337,344

RESOURCES

As of December 31, 1976, domestic measured and indicated helium resources were estimated at 262.5 billion cubic feet. The resources include measured and indicated reserves estimated at 98.8 and 50.4 billion cubic feet, respectively, in natural gas with a minimum helium content of 0.3%. The remaining resource base included 39.1 billion cubic feet stored in the Bureau's conservation storage system and 74.2 billion cubic feet of helium in measured natural gas reserves with a helium content of less than 0.3%. Approximately half of the domestic helium reserves are under Federal lease. Included are the Tip Top and Church Buttes fields in Wyoming, the Keyes field in Oklahoma, and the Cliffside field in Texas.

The majority of domestic helium reserves are located in the midcontinent and Rocky Mountain regions of the United States. A total of 78 gasfields in 10 States contain measured and indicated helium reserves. About 86% of these reserves are located in the Hugoton field in Kansas, Oklahoma, and Texas; the Keyes field in Oklahoma, the Panhandle and Cliffside fields in Texas, and the Tip Top field in Wyoming. Approximately 54% of the measured and indicated reserves (0.3% or greater helium content) at yearend 1976 were in currently producing gasfields. In 1976, about 18% of the helium-rich natural gas (0.3% or greater helium content) produced was processed for helium extraction. Helium produced from the remaining helium-rich natural gas output was dissipated incident to the consumption of the gas.

The Bureau examined a total of 328 gas samples from 20 States during 1976 in connection with its efforts to survey and identify possible new sources of helium supply. None of the samples collected and analyzed indicated the presence of major new deposits of helium.

FOREIGN TRADE

Exports of high purity helium, all by private industry, totaled 174 million cubic feet in 1976, up 21% from 1975. Countries of Western Europe received 75% of the exports, as follows: Belgium-Luxembourg, 32%; the United Kingdom, 32%; and France, 11%. Exports to Japan and Australia were 9% and 2%, respectively. Canada accounted for about 2% of the exports. The continued increase of helium exported to Western Europe during 1976 was attributed primarily to its use in the exploration for and development of oil and gas deposits, especially in the North Sea area.

Table 8.—Exports of high purity helium from the United States

(Million cubic feet)

Year	Quantity
1972	e112
1973	e117
1974	e129
1975	[1]144
1976	[1]174

eEstimate.
[1]Bureau of the Census.

WORLD REVIEW

World production of helium exclusive of the United States, totaled an estimated 150 million cubic feet in 1976. Canada produced about 35 million cubic feet from a plant in Saskatchewan owned by Canadian Helium, Ltd. Production from a plant near Paris, France, was about 15 million cubic feet. The U.S.S.R. and the Central Economy Countries of Europe produced an estimated 100 million cubic feet, unchanged from the 1975 estimate.

It was reported that a fire in the methane gas drainage section of the helium extraction plant at Odolanow, Poland, in September 1975 caused a 9-month delay in the plant construction schedule. Repair and construction continued during 1976, and it was expected that this 150-million-cubic-foot-per-year plant would be operational by the spring of 1977. This plant is a complex designed to process natural gas containing 45% nitrogen and 0.4% helium. A U.S. firm, Airco, Inc., has a contract to market all helium exported from this plant.

TECHNOLOGY

Measurements of dissolved helium were made in water samples collected from several selected lakes and ponds in the Kaipokok region of Labrador, Canada. The purpose of research by McMaster University and private industry was to determine amounts of excess helium-4 from the decay of uranium and its daughter products and the relationship with surrounding uranium mineralization. The mapped quantities of helium-4 indicated a close correlation with known uranium mineralization, thus pointing up a possible new method of uranium prospecting.

New medical applications of helium have recently been developed. One new use is in a helium-filled, intra-aortic ballon device which represents promising therapy for the treatment of cardiogenic shock. Another application is a helium-breathing apparatus used as a diagnostic tool for pulmonary testing. This test most often reveals abnormalities connected with lung disease which might otherwise go undetected by routine physical examination.

Projects underway at Goodyear Tire & Rubber Co. in the United States and, in West Germany by another firm, involved testing models of helium cargo blimp aircraft capable of lifting 40- to 100-ton loads. The prototypes were constructed of a rubberized, high-tenacity fabric to contain the helium gas and provide strength necessary for heavy lifting. Flights of this type of blimp were also conducted in Ghana and other African areas so as to test the ability of the craft to operate in climactic extremes of heat and humidity. In addition, the U.S. Coast Guard was investigating the use of helium cargo blimps for possible surveillance of U.S. territorial waters.

Iron Ore

By F. L. Klinger[1] and C. T. Collins[2]

World production and trade of iron ore in 1976 were close to the levels of 1975. Production was estimated at 881 million long tons,[3] and trade was estimated at 365 million tons of which about 290 million tons was oceanborne. Demand for iron and steel increased in the United States and some other countries in 1976, but the additional ore required was largely available from producers' or consumers' stocks which had accumulated during 1975. There were noteworthy increases in production of ore in the Republic of South Africa, Canada, and Brazil, but these resulted from completion of new projects begun in previous years rather than from increased demand during the year. Production declined in some major producing countries such as Australia, France, and Venezuela, and the volume of trade appeared to be sustained mainly by commitments of consumers under previously negotiated contracts.

The leading producing countries in 1976 were the U.S.S.R., Australia, Brazil, and the United States, in that order. Brazil became the third largest producer in 1975 and increased production in 1976. Australia remained the leading exporter of iron ore, followed by Brazil. Canadian exports increased by 8 million tons in 1976 and probably exceeded those of the Soviet Union.

World output of iron ore pellets was estimated at 172 million long tons in 1976. Production capacity was increasing, as new plants or expansion projects were completed or nearing completion in the United States, Brazil, and Canada. Direct-reduction plants were completed or under construction in several countries in North and South America, Europe, and the Middle East. The use of flotation and high-intensity magnetic separation processes for beneficiating iron ore continued to grow. In the United States, the substitution of coal for natural gas or fuel oil in iron ore pelletizing was being intensively studied by the Bureau of Mines as well as by private companies.

In transportation, almost always a major element in the delivered cost of iron ore, efforts to reduce costs by the use of unit trains, larger capacity vessels, development of port facilities capable of handling larger ships, and installation of large-volume materials-handling systems at inland and coastal locations continued in 1976. A 240-mile slurry pipeline for iron ore concentrates was completed in Brazil, and shorter pipelines were completed or under construction in Mexico and Argentina.

Iron ore prices continued to rise in 1976. Most increases were about 10% to 15% above the 1975 prices. Prices for Swedish ores declined, particularly for high-phosphorus grades; this appeared to cause some realignment of production plans in Sweden, as well as concern by French iron ore producers that low prices for Swedish ores may reduce demand for French ores in domestic or intra-Community markets.

Ocean freight rates for iron ore appeared to remain close to the relatively low levels of 1975, but there were some rising trends evident in 1976, and published rates from Australia to Europe were markedly higher. Lake freight rates increased about 12% in the United States, but rail freight rates were essentially unchanged.

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[1]Supervisory physical scientist, Division of Ferrous Metals.
[2]Commodity specialist, Division of Ferrous Metals.
[3]Unless otherwise stated, the unit of weight used in this chapter is the long ton of 2,240 pounds.

Table 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Iron ore (usable,[1] less than 5% manganese):					
Production[2]	75,434	87,669	84,355	78,866	79,993
Shipments	[3]77,884	[3]90,654	[3]84,985	[3]75,695	[2]77,076
Value	[3]$950,365	[3]$1,163,710	[3]$1,388,447	[3]$1,620,599	[2]$1,871,114
Average value at mines per ton	$12.20	$12.84	$16.34	$21.41	$24.28
Exports	2,095	2,747	2,323	2,537	2,913
Value	$26,776	$37,922	$35,148	$60,071	$82,192
Imports for consumption	35,761	43,296	48,029	46,743	44,390
Value	$415,934	$533,488	$696,298	$860,496	$980,348
Consumption (iron ore and agglomerates)	126,943	146,922	138,160	114,126	125,424
Stocks Dec. 31:					
At mines	14,679	10,876	9,405	12,299	13,993
At consuming plants	50,061	45,990	45,247	52,231	56,246
At U.S. docks	2,612	3,053	3,272	4,614	4,763
Manganiferous iron ore (5% to 35% manganese): Shipments	131	181	[r]244	142	221
World: Production	765,465	832,343	[r]883,834	[r]887,389	881,028

[r]Revised.
[1]Direct shipping ore, concentrates, agglomerates, and byproduct ore (mainly pyrite cinder and agglomerates).
[2]Includes byproduct ore.
[3]Excludes byproduct ore.

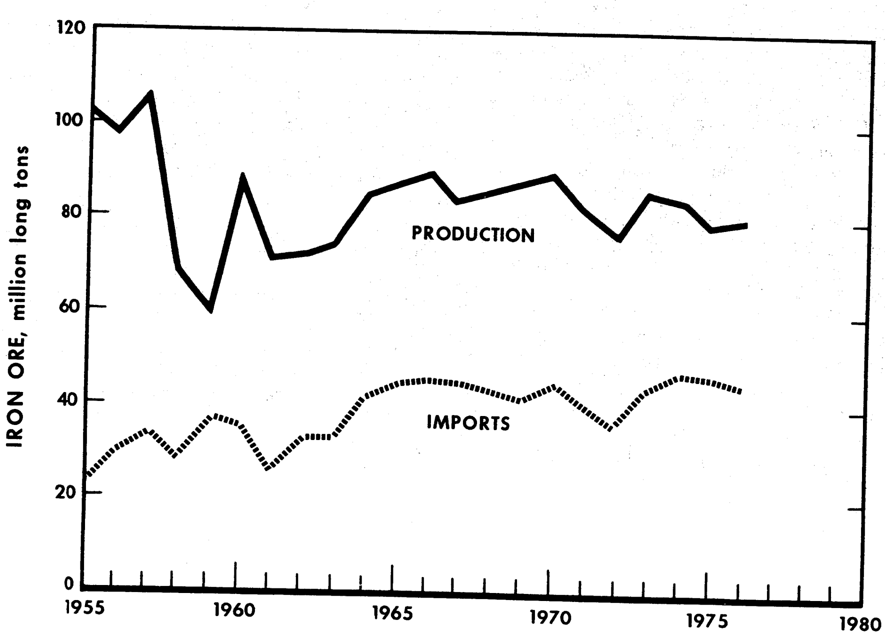

Figure 1.—United States iron ore production and imports for consumption.

EMPLOYMENT

Statistics on employment and productivity in the iron ore industry in 1976 are shown in table 2. Employment data were supplied by the Mining Enforcement and Safety Administration (MESA). In table 2, statistics for all States outside the Lake

Superior district were aggregated to avoid disclosure of individual company confidential information.

The average number of persons employed in 1976 was 20,456, compared with 19,900 in 1975. The increase of 2.8% was largely due to increasing employment in Minnesota and Michigan, where several new production facilities for taconite were completed. Compared with 1975, average productivity for crude ore in 1976 rose about 4%, owing to the increasing share of taconite in domestic crude ore production. Average productivity for usable ore rose 1%.

As in previous years, statistics published in table 2 do not include office workers. The number of office workers at mines and beneficiation plants in 1976 was approximately 2,770.

DOMESTIC PRODUCTION

U.S. mine production and shipments of usable iron ore in 1976 increased 1.4% compared with those of 1975. Output of usable ore, including byproduct ore, was just under 80 million tons. Shipments totaled 77.1 million tons, valued (f.o.b. mine) at approximately $1.87 billion.

Output of crude iron ore totaled 224 million tons in 1976, an increase of 4.4% compared with that of 1975. The increase was due mainly to increased production of taconite in Minnesota and Michigan. Nationwide, the number of producing mines included 58 open pit and 6 underground mines. As in 1975, open pit mines accounted for 96% of the total output, and 99% of all ore produced was shipped to beneficiation plants. Average iron content of crude ore produced was approximately 32.7%. Beneficiating facilities, at or near mine sites, processing domestic crude ores in 1976, included 17 concentrators with associated pelletizing plants (7 in Minnesota, 4 in Michigan, 2 in Missouri, and 1 each in California, Pennsylvania, Wisconsin, and Wyoming) mostly processing ores of the taconite type; 1 plant screening, drying, and pelletizing natural ore; 1 plant pelletizing byproduct ore; 1 sintering plant; and an estimated 24 plants producing concentrates primarily by gravity methods, of which 14 were located on the Mesabi range. Nationwide, the number of tons of crude ore mined for each ton of usable ore produced in 1976 was 2.82, compared with 2.72 in 1975 and 2.57 in 1974.

Production of usable ore in 1976 consisted 81% of pellets, 17% of natural ore concentrates, and 2% of direct-shipping ore. The average natural iron content of all usable ore produced (including byproduct ore) was 61.7%. The Lake Superior district accounted for 84% of the national output. Minnesota produced 62%, Michigan 21%, and the remainder was produced in 15 other States.

In Minnesota, Hibbing Taconite Co. began production of pellets in late 1976. The plant has a production capacity of 5.4 million tons of pellets per year and was the seventh major taconite facility to be completed in Minnesota since 1965. Major expansions of taconite-processing plants at Eveleth and Keewatin were also completed by yearend; annual production capacity for pellets at Eveleth was raised by 3.6 million tons, and that at Keewatin was raised by 3.0 million tons. Additional ore requirements at Eveleth were supplied by a new mine developed for Eveleth Expansion Co., while those at Keewatin were supplied by expansion of the existing mine operated for the National Steel Pellet Project. At Mountain Iron, work was continued by United States Steel Corp. to raise production capacity of its Minntac facility by 6 million tons of pellets per year; this project was expected to be completed in 1978. At Virginia, construction of the Minorca taconite project by Inland Steel Co. was scheduled for completion in the spring of 1977; this facility will have a production capacity of 2.6 million tons annually and will raise the number of operating taconite plants in Minnesota to eight. All of the projects are based on magnetite ore.

The proposal by Reserve Mining Co. to provide for on-land disposal of taconite tailings at "Milepost 7," near the company's existing plant at Silver Bay, Minn., had not been approved by Minnesota State authorities by yearend. State agencies continued to advocate disposal sites farther north, the cost of which the company considered prohibitive. If the dispute could not be resolved by July 1977, the company would be forced by court order to cease production.

In Michigan, the Cleveland-Cliffs Iron Co. confirmed plans to expand annual production capacity for pellets by 4 million tons at the Tilden mine and by 2.8 million tons at the Empire mine by 1981. Cost of the expansion projects was estimated at $750 million, including $300 million at Tilden, $250 million at Empire, and $200 million for installation of an additional 250 megawatts of electricity-generating capacity at the company's Marquette powerplant.

Unusually cold weather in the midwestern United States caused drastic curtailments of natural gas supplies to pelletizing plants in the Lake Superior district. Curtailments began on October 18, 1976, and continued through December. Most plants were equipped to switch over to fuel oil, so that overall production in the district was not seriously affected, but higher prices of alternate fuels (including "intrastate" natural gas, as well as fuel oil) drove up costs of production and increased upward pressures on prices. These developments also focused attention on the need for some producers to use alternate sources of energy, such as coal.

In Missouri, more than 2 million tons of magnetite ore were blasted in the Pea Ridge underground mine on two occasions in 1976. On December 11, the second blasting operation, which included 3,140 drill holes and portions of four mine levels, used 1.066 million pounds of water-gel explosives to break 2.98 million tons of pillar ore, believed to be the largest quantity ever blasted in a U.S. underground iron mine.

In New Jersey, plans to reopen the Mt. Hope underground mine near Dover were announced by Mt. Hope Mining Co., Inc. Production of magnetite concentrates was expected to begin in 1977, eventually reaching an annual rate of about 400,000 tons, the concentrates to be purchased by Bethlehem Steel Corp. The venture was being financed mainly by loans totaling about $7.5 million. The Mt. Hope mine was last operated by Shamoon Industries, Inc., in 1959.

CONSUMPTION

Consumption of iron ore and agglomerates in 1976 increased about 9.9%, compared with that in 1975. Consumption in blast furnaces increased 10%, while that in steelmaking furnaces increased 6.6%. Of total consumption, blast furnaces accounted for 98.3%; steelmaking furnaces, 1%; and the remaining 0.7% was used in the manufacture of cement, heavy-media, and other miscellaneous products. In blast furnaces, the weight ratio of iron ore and agglomerates consumed to pig iron produced was approximately 1.57:1 compared with 1.56:1 in 1975.

The quantity and proportion of iron ore pellets consumed continued to increase. Pellets made up 60% of all iron ore and agglomerates consumed in 1976 and 70% of all agglomerates consumed. Sinter made up 27% of all iron ore and agglomerates consumed, and natural ores accounted for the remaining 13%.

Consumption data are shown in tables 11 and 12. In these tables, iron ore concentrate used to produce agglomerates such as pellets or sinter at mine sites is not reported as iron ore consumed; its consumption was reported only when such agglomerate was used at the furnace site (table 11). Iron ore concentrate and fines used to produce sinter at iron and steelmaking plants are reported in table 12 as iron ore consumed, while consumption of agglomerates from this source is included in table 11. In table 12, the difference in weight between iron ore consumed and agglomerate produced results from the elimination of moisture as well as the addition of materials such as flue dust, mill scale, lime, and coke.

STOCKS

Stocks of iron ore and agglomerates at U.S. mines, docks, and consuming plants totaled 75 million tons on December 31, 1976. This was 8.5% more than a year earlier and was the highest yearend total since 1971. Monthend stocks of ore at consuming plants during 1976 ranged from a low of 35 million tons in April to a high of 55 million tons in November, while those at the mines ranged from a high of 22.7

million tons in April to a low of 13.5 million tons in November. Of the 56.8 million tons on hand at U.S. docks and furnace yards at yearend, 58% consisted of domestic ores, 19% of Canadian ores, and 23% of other foreign ores.

A gain of 4.2 million tons of ore in stocks at U.S. docks and furnace yards was apparent by the end of 1976. This occurred despite an increase in domestic consumption, a decrease in ore imports, and only a slight increase in domestic mine and lake shipments compared with 1975. While the apparent statistical anomaly was not resolved by yearend, it was possibly due to stockpiling of unsold foreign ore at some locations in the United States. According to a report published in 1976 by the Venezuelan Ministry of Mines and Hydrocarbons, 1.1 million metric tons of unsold Venezuelan ore was stockpiled in the United States during 1975.

PRICES

Published prices for Lake Superior iron ores (delivered rail-of-vessel at lower lake ports) increased twice during 1976. In January, prices increased about 4% for natural ores and 6.9% for pellets, compared with prices in effect at yearend 1975. Another increase, amounting to about 5.2% for all grades, was instituted in August, after which prices were unchanged during the remainder of the year. Prices in effect from the latter half of August through December 31, 1976, were, for natural ores (basis 51.5% Fe, natural), per gross ton: Mesabi non-Bessemer, $20.26; Mesabi Bessemer, $20.41; Old Range non-Bessemer, $20.51; and manganiferous, $20.51. A premium of 80 cents per ton continued to be paid for coarse ore, and a penalty of 45 cents per ton was charged for fines. The price of iron ore pellets in late August was 53.1 cents per long ton unit of contained iron, natural. Any increases in the cost of transportation and handling subsequent to the effective dates of these prices (August 6 to August 16, 1976, depending on the producer) were to be borne by the buyer.

The average value (f.o.b. mine or concentrating plant) of usable iron ore shipped from domestic mines in 1976 was $24.28 per long ton, compared with $21.41 in 1975 and $16.34 in 1974. These values were calculated from producers' statements and approximated the commercial selling price less costs of mine-to-market transportation.

Prices for many foreign iron ores also increased in 1976. In Canada, the price of Wabush iron ore pellets, f.o.b. Pointe Noire, Quebec, in August 1976 was 47.2 cents per long ton unit of contained iron and manganese, an increase of about 12.5% compared with the price at yearend 1975. In Australia, prices paid by Japanese steelmakers under several contracts for iron ore pellets were increased 13% to 26% as of April 1, 1976; under these agreements the f.o.b. price (per dry long ton unit of contained iron) of Hamersley pellets rose to 34 cents; of Savage River pellets, to 35.1 cents; and of Robe River pellets, to 38 cents. Similarly, under a natural-ore contract with Mt. Newman Mining Co. Pty. Ltd., the Japanese agreed to pay f.o.b. prices of $15.19 per dry long ton for lump ore (64% Fe) and $11.87 for fines (62% Fe), beginning October 1, 1976; these prices were 15% higher than those paid in 1975. Price increases were also negotiated by Indian and Brazilian producers with Japanese buyers in 1976.

In contrast, contract prices for Swedish phosphoric ores declined in 1976. Prices under contracts negotiated by Belgian consumers in early 1976 were reported to be 4% to 9% below 1975 levels. The price of Kiruna D iron ore (60% Fe, 1.8% P), c.i.f. Rotterdam, was approximately $16.10 per metric ton on June 30, 1976, compared with $19.30 per ton a year earlier.

The f.o.b. value of Venezuelan iron ore exported to the United States, as indicated by U.S. Bureau of the Census data, averaged $16.85 per long ton in 1976, compared with $15.63 in 1975.

TRANSPORTATION

Iron ore shipments from U.S. ports on the Great Lakes to lower lake destinations in 1976 totaled 63.1 million tons, 0.8% more than in 1975. Shipments of ore from Canadian ports to Great Lakes destinations totaled 23.6 million tons, an increase of 34% compared with that of 1975. Nearly 90% of the increase in shipments from Canada came from the ports of Pointe Noire, Sept-Iles, and Port Cartier, each of which shipped nearly 2 million tons more than in 1975. Total shipments from U.S. and Canadian ports to lake destinations (86.7 million tons) in 1976 were 8% more than in 1975.

With the help of icebreaking and other navigational aids, the second consecutive 12-month ore-shipping season was completed between Two Harbors, Minn., and lower lake ports in March 1976. Shipments from Two Harbors totaled 568,000 tons in February and 294,000 tons in March. Shipping from other ports on Lake Superior had stopped by January 10. Efforts to extend the 1976 shipping season were hampered by unusually cold weather, and the final ore shipment was made on January 21, 1977.

Statistics on shipments of iron ore from U.S. ports on the Great Lakes during the 1976 season are shown in the accompanying tabulation:

Lake shipping port	Number of vessels loaded[1]	Total tonnage shipped[1] (thousand long tons)	Average cargo (long tons)[1]	Largest cargo (long tons)
Duluth, Minn	784	14,050	17,921	30,709
Taconite Harbor, Minn	358	10,254	28,643	58,558
Silver Bay, Minn	565	9,694	17,158	31,042
Two Harbors, Minn	262	7,506	28,650	53,920
Superior, Wis	282	6,145	21,792	25,359
Marquette, Mich	280	5,437	19,416	30,830
Escanaba, Mich	514	10,061	19,574	40,475
Total or average	3,045	63,147	20,738	XX

XX Not applicable.

[1]Not including shipments in January 1977, as follows: Two Harbors, 17 vessels (471,094 tons); Escanaba, 8 vessels (167,266 tons); and Marquette, 7 vessels (107,651 tons).

Sources: Skillings' Mining Review, various issues (1977); and Annual Report of Lake Carriers Association for 1976.

Lake freight rates for iron ore were increased in February 1976 to the following values (per gross ton): From the head of the lakes to lower lake ports, $4.05; from Marquette, Mich., to lower lake ports, $3.34; from Escanaba, Mich., to Lake Erie ports, $3.05; and from Escanaba to lower Lake Michigan ports, $2.43. These rates remained in effect through December 1976 and were 8.6% to 9.7% higher than rates prevailing in 1975. Most storage, handling, and dock charges were unchanged from 1975, although unloading charges (rail of vessel to car) at lower lake ports were increased 2% to 7%, and dockage charges for self-unloading vessels at Conneaut and Lorain, Ohio, increased about 10% during the year. The vessel freight rate from the Gulf of St. Lawrence to Lake Erie ports (excluding St. Lawrence Seaway and Welland Canal tolls) remained unchanged at $1.70 per gross ton.

Most domestic rail freight rates for iron ore were unchanged from 1975 levels. Rates for some routes from lower lake ports to inland destinations were increased less than 3%; the rate from Baltimore to Fairless, Pa., was increased about 9%; and there were slight reductions in some rates from Lake Erie ports to the Mahoning and Shenango valleys, and from Philadelphia to Detroit.

The 1,000-foot, self-unloading iron ore carrier *James R. Barker* began service on the Great Lakes in August 1976 and by late December had transported 1.2 million tons of iron ore pellets from Lake Superior to lower lake ports, including a record shipment of 58,558 tons from Taconite Harbor, Minn. The vessel was operated by Interlake Steamship division of Pickands Mather & Co. and was the third carrier of its size to enter lake service. Six more vessels of this type were under construction for various companies in 1976. In July, the new self-unloading ore carrier *Joseph L. Block* began service for Inland Steel Co.; the vessel was stated to have a cargo capacity of 31,000 tons but was reportedly carrying up to 35,000 tons of pellets from Escanaba.

Ocean freight rates from Canadian ports on the Gulf of St. Lawrence to U.S. east coast and gulf coast ports in 1976 appeared to be unchanged from the low levels of 1975, while rates to Europe and Japan appeared to vary slightly from those of 1975. Spot fixtures reported by Metal Bulletin indicated rates from Sept-Iles as follows: To Japan, $4.10 to $4.25 per ton for cargoes of 140,000 to 150,000 tons during the last 4 months of 1976 (compared with $4.60 in October 1975); to the Netherlands, $2.30 per ton for 80,000 tons in July and $1.97 to $2.20

per ton for cargoes of 125,000 tons in October (compared with $2.05 to $2.45 for cargoes of 79,000 to 90,000 tons in early 1975); and to West Germany, $3.00 to $3.30 per ton for cargoes of 70,000 to 75,000 tons in November and December (compared with $2.80 for 60,000 tons in October 1975). Rates from Brazil and Liberia to Western Europe appeared to increase slightly in 1976, but no strong trend was evident; rates from Tubarão to Dunkirk ranged from $3.65 to $3.95 per ton for cargoes of 68,000 to 90,000 tons, and rates from Monrovia (Liberia) to the Netherlands were $2.75 to $2.90 per ton for cargoes of 80,000 to 95,000 tons. Two shipments from Tubarão to Japan ranged from $3.80 to $4.25 per ton for cargoes of 110,000 to 140,000 tons. Rates from Australia to Western Europe appeared to increase sharply; rates of $5.00 to $6.15 per ton were reported for shipments of 100,000 to 145,000 tons from Cape Lambert to the Netherlands, compared with $3.50 per ton for 125,000 to 130,000-ton cargoes in 1975. Rates quoted for two shipments of 50,000 tons from Brazil and Liberia to the U.S. east coast were $3.00 and $4.20 per ton, respectively.

In the Republic of South Africa, exports of iron ore began from Saldanha Bay in 1976. The initial shipment, 119,000 tons of hematite ore destined for Rotterdam, was made on September 27.

FOREIGN TRADE

U.S. exports of iron ore in 1976 totaled 2.9 million tons valued at approximately $82 million. These quantities represented a 15% increase in tonnage and a 37% increase in value compared with 1975 figures. Virtually all exports were destined for Canada. As several Canadian steel companies held significant ownership shares in U.S. taconite projects completed or under construction in 1976, exports to Canada were expected to increase during the next several years. Average value of exported ore in 1976 (principally pellets) was $28.22 per long ton, compared with $23.68 in 1975 and $15.13 in 1974.

U.S. imports of iron ore for consumption in 1976 totaled 44.4 million tons, valued (f.o.b. country of origin) at $980 million. The tonnage imported was about 5% less than in 1975, but the total value was 14% greater and reflected rising prices of foreign iron ores. Average value of ore imported in 1976 was $22.08 per long ton, compared with $18.41 in 1975 and $14.50 in 1974. Principal countries of origin were Canada, accounting for 56% of the total tonnage; Venezuela, 20%; Brazil, 12%; and Liberia, 5%. Compared with 1975, imports from Canada increased by 5.85 million tons, while those from Venezuela and Brazil declined by 4.1 and 2.2 million tons, respectively.

Imports from Peru in 1976 were less than half of the quantity imported in 1975. Imports from that country were halted in August 1975 following nationalization of Peruvian properties of Marcona Mining Co. and did not resume until a compensation agreement acceptable to Marcona had been reached. Imports were resumed in April 1976.

The Philadelphia customs district received about 22% of U.S. iron ore imports in 1976, followed by Baltimore (21%), Cleveland (17%), Chicago (14%), Mobile (10%), Buffalo (8%), Detroit (4%), and eight other districts (4%).

World trade in iron ore in 1975 is shown in table 21.

WORLD REVIEW

Australia.—Production of iron ore declined about 4% in 1976, but exports (79.7 million tons) were slightly greater than in 1975. Shipments of iron ore products to domestic and foreign markets in 1976 totaled about 94 million tons, including 9 million tons of pellets. Consumption of iron ore in Australia was estimated at about 10.5 million tons.

Approximate shares of individual Australian producers in total shipments of ore products in 1976 were as follows: Hamersley Iron Pty. Ltd., 38%; Mt. Newman Joint Venture, 29%; Cliffs Robe River Iron Associates, 13%; Broken Hill Pty. Co. Ltd. (BHP), 9.5%; Goldsworthy Mining Ltd., 8%; and Savage River Mines, 2.5%.

Annual production capacity for ore products in 1976 totaled about 122 million metric tons, distributed as follows: Hamersley, 40; Mt. Newman, 40; Robe River, 16; BHP, 15.5; Goldsworthy, 8; and Savage River, 2.5. Production capacity of Hamersley will increase by about 6 million tons by 1979 when the concentrator for low-grade ore is completed at Mount Tom Price. The plant will include heavy-media and wet high-intensity magnetic separation sections and was designed to process about 11 million tons of crude ore per year. The decision to build the plant followed negotiation of supply contracts with Japanese consumers for an additional 185 million tons of ore between 1978 and 1990, as well as other supply contracts with European and Asian consumers.

Five 226-ton-capacity trucks began service at Mount Tom Price during 1976, and 15 150-ton trucks were ordered for the Paraburdoo mine.

Cyprus Mines Corp. reportedly sold a 10% interest in Mt. Goldsworthy Mining Associates to Mount Isa Mines Holdings, Ltd., in 1976 and agreed in principle to sell the remainder of its one-third interest in Mt. Goldsworthy to Consolidated Gold Fields Ltd. of London.

Brazil.—Statistics published by the Brazilian Ministry of Mines indicated that Brazilian output of beneficiated iron ore totaled about 88 million tons in 1975. Preliminary data indicated that production increased in 1976 although exports declined to about 66 million tons. Brazil thus appeared to have displaced the United States as the world's third largest iron ore producer in 1975 and was rivaling Australia in both production and exports.

Total shipments of iron ore products in 1976 were estimated at about 81 million tons, including 69 million tons destined for export and 12 million tons for domestic consumption. The principal shippers were Companhia Vale do Rio Doce (CVRD), 49.8 million tons; Mineracoes Brasileiras Reunidas (MBR), 13.4 million tons; S.A. Mineração da Trindade (SAMITRI), 7.8 million tons; and Ferteco Mineracão S.A., 4.3 million tons. Brazilian stocks of ore products exceeded 12 million tons at yearend.

Pellet production in 1976 may have exceeded 5 million tons. CVRD produced 4.6 million tons in two plants operated at Tubarão. Ferteco Mineracão S.A. completed construction of a pelletizing plant at the Fabrica mine in 1976. Output capacity of the plant was 2.5 million tons of pellets per year. Pellet production was expected to increase in 1977, as two plants with a total annual production capacity of 8 million tons were scheduled for completion. One of the latter was a joint venture by CVRD with Italian companies; the other was a 5-million-ton facility being built for Samarco Mineracão S.A. The Samarco project, scheduled for completion in mid-1977, was to have an initial production capacity of 7 million tons annually, including 5 million tons of pellets and 2 million tons of pellet feed. Concentrate produced by flotation at the Germano mine was to be pumped through a 20-inch, 240-mile pipeline to pelletizing and shipping facilities at Ponta Ubu.

A direct-reduction plant with production capacity of 360,000 metric tons of sponge iron per year was being built 50 miles west of Rio de Janeiro by Companhia Siderurgica da Guanabara (COSIGUA) in 1976. Production was expected to begin in 1977. The plant will use the Purofer reduction process and reportedly will be the first commercial direct-reduction plant fueled by gas produced from heavy fuel oil. Ore feed to the plant was to be supplied from the Feijao mine of Ferteco and the Mutuca mine of MBR. Two direct-reduction plants were already operating in Brazil in 1976, in Bahia and Rio Grande do Sul.

CVRD reported negotiation of new long-term iron ore supply contracts totaling more than 300 million tons in 1976.

Canada.—Production and exports of iron ore in 1976 increased about 20% and 26%, respectively, compared with those of 1975. The increase in output amounted to 9.9 million tons and was due mainly to the first year of production at Mt. Wright, where 6 million tons of concentrates was produced by Quebec Cartier Mining Co. Production of concentrates and pellets at Carol Lake by the Iron Ore Co. of Canada and of pellets at Pointe Noire by Wabush Mines was substantially greater than in 1975, and increased output was reported from most other Canadian mines and plants. Exports of iron ore to the United States increased nearly 5 million tons in 1976, while exports to Japan and Western Europe rose about 4 million tons. Consumption of iron ore in Canada in 1976 totaled 13.5 million tons, of which 81% was pellets.

Production of concentrates was expected to increase in 1977 as output from Mt. Wright approached design capacity. Production from the Mt. Wright deposits was scheduled to replace that from Lac Jeannine, where reserves were expected to be exhausted by mid-1977. Production capacity for pellets was scheduled to increase by 6 million tons in late 1977, upon completion of two pelletizing plants at Port Cartier. Iron Ore Co. of Canada will probably increase output of pelletized concentrate from Schefferville ores at Sept-Iles; output increased 15% in 1976, but the plant was still producing well below its designed capacity. Hilton Mines Ltd. was expected to cease operations in mid-1977 owing to exhaustion of ore reserves.

In other developments, Texada Mines Ltd. ceased operations in British Columbia in December 1976 owing to exhaustion of ore reserves. At Tasu, British Columbia, Wesfrob Mines decided to develop underground ore reserves in order to continue production for another few years. In Ontario, the direct-reduction plant at the Griffith mine was operated from January through March and intermittently thereafter until August, when it was closed owing to operating problems and market conditions. The plant produced about 76,000 tons of prereduced ore during 1976. The direct-reduction plant of Sudbury Metals at Falconbridge, Ontario, was officially opened on May 12, 1976, but was shut down in October following an explosion. A 67% interest in Steep Rock Iron Mines, Ltd. was reportedly acquired by Canadian Pacific Investments, Ltd., in 1976 for $16.2 million.

European Community (EC).—The principal steelmaking countries of the EC imported 127.9 million tons of iron ore in 1976. West Germany imported 36% of the total, followed by Belgium-Luxembourg (20.8%), the United Kingdom (14.5%), Italy (13%), France (10.7%), and the Netherlands (5%). Imports by Belgium-Luxembourg and West Germany included about 12.5 million tons of ore containing less than 42% iron, mostly from France. Imports of iron ore by Denmark and Ireland were negligible.

Production of iron ore in the EC in 1976 totaled about 54 million tons, of which France produced about 82%. Almost all of this ore was low grade, containing 25% to 32% Fe, and was used for consumption within the EC, in France, Belgium, Luxembourg, and West Germany.

Consumption of iron ore in the EC during the first 9 months of 1976 totaled 107.9 million tons, about 4% more than in the comparable period of 1975. Total consumption of iron ore in 1975 was 154.7 million tons, of which about 77% was consumed in agglomerating plants at iron and steelworks, 22% was charged directly into blast furnaces, and 1% was charged directly into steelmaking furnaces.

Korf Stahl AG of West Germany and A/S Sydvaranger of Norway signed a contract in 1976 for construction of a direct-reduction plant at Emden, West Germany. The plant is to have a production capacity of 1.2 million tons of direct-reduced iron per year and was scheduled for completion in 1980. Iron ore will be supplied by A/S Sydvaranger, and the plant will be fueled by natural gas piped from the Norwegian sector of the North Sea. The operating company will be Norddeutsche Ferro Werke G.m.b.H., owned 75% by A/S Sydvaranger and 25% by Korf Stahl.

Construction of a direct-reduction plant at Hunterston, Scotland, was continued by the British Steel Corp. in 1976. The plant will use the Midrex process and will consist of two modules, each having a production capacity of 400,000 tons of direct-reduced iron per year. The first module was scheduled for completion in 1977.

Finland.—The newly opened Rautavaara mine had its first full year of production in 1976. After a period of open pit mining, underground production began when the mine shaft and hoist were completed in the summer. Production totaled 779,000 tons of crude ore and 354,000 tons of concentrates. The concentrates were shipped to the blast furnaces of Rautaruukki Oy. at Raahe. The latter plant also received 243,000 tons of iron concentrates from the Otanmäki mine, as well as pelletized iron oxide and "purple ore" recovered from sulfide-processing at Kokkola.

India.—Production and exports of iron ore in 1976 were little changed from 1975 levels. Exports were estimated at 22.8 million tons, with about 74% destined for Japan and 10% destined for Romania. Domestic consumption was approximately 16.4 million tons.

Development of the Kudremukh iron ore deposits near Mangalore began in 1976. Canadian Met-Chem Consultants, Ltd., will develop the deposits for Kudremukh Iron Ore Co. Ltd., a public sector company organized under the Indian Ministry of Steel and Mines. Met-Chem will design and supervise construction of a mine, concentrator, 35-mile slurry pipeline, and port facilities at Mangalore capable of producing and loading into vessels 7.5 million tons of concentrate per year for shipment to Iran. Construction was expected to be completed by early 1980. Met-Chem will supervise all operations for the first 3 years of commercial production.

In other developments, port facilities capable of berthing and loading ore carriers of 100,000 deadweight tons were completed at Visakhapatnam outer harbor in late 1976. The National Minerals Development Corp. Ltd. announced that construction of the Bailadila No. 5 mine and plant, with production capacity of 4 million tons per year, was completed in 1976. In Goa, the pelletizing plant being built near Mormugao port by a subsidiary of Chowgule & Co. Ltd. was scheduled for completion in 1977. The plant is to have a production capacity of 1.8 million tons of pellets per year.

Japan.—Imports of iron ore by Japan in 1976 totaled 131.6 million tons. The principal source countries were Australia, which supplied 48% of the total, followed by Brazil (19%), India (13%), Chile (5.7%), and Canada (4%). Pellets made up about 8% of total imports. An additional 6.5 million tons of pellets were produced in Japan, principally from imported ores.

Consumption of iron ore in 1976 totaled 122.8 million tons, including 8.6 million tons of imported pellets. Most of this ore was apparently used in the manufacture of sinter and other agglomerates. Consumption of agglomerates in blast furnaces totaled 115 million tons.

Liberia.—Production of iron ore declined more than 20% in 1976, but exports increased about 6% compared with those of 1975. Exports totaled about 19.2 million tons, of which 48% was shipped by the LAMCO Joint Venture, 32.5% by Bong Mining Co., 10.5% by National Iron Ore Co., and 9% by Liberia Mining Co. (LMC). Production by LMC declined sharply in 1976, and operations were scheduled to cease in early 1977 owing to exhaustion of ore reserves. Bong Mining Co. expected to complete expansion of its pelletizing facilities in 1977, to a total production capacity of more than 4 million tons annually. Stocks of ore held by Liberian producers declined during 1976 but totaled at least 5 million tons at yearend.

Mexico.—Production of iron ore increased sharply in 1976 as two concentrating plants began operating in the early part of the year. Near Durango, a new concentrator was brought onstream at the Cerro de Mercado mine by Fundidora de Monterrey S.A. The plant was equipped with a flotation section and magnetic separators, and had a production capacity of about 1.7 million tons of concentrate per year. Concentrate was shipped by rail to Monterrey, where a pelletizing plant was also completed by the company in 1976. Production capacity of the latter plant, which employs the grate-kiln system designed by Allis-Chalmers, was 1.5 million tons per year of self-fluxing pellets.

In Michoacan, concentration of magnetite ore was begun at the Ferrotepec mine by Siderurgica Lazaro Cardenas-Las Truchas S.A. (SICARTSA). Production capacity of the plant was 1.5 million tons of concentrate per year. Concentrate was transported by a 10-inch pipeline 16 miles to a pelletizing plant at the steelworks in Lazaro Cardenas.

Production capacity of the pelletizing plant completed in 1975 by Consorcio Minero Peña Colorada S.A. will be increased to 3 million tons annually in 1978. Shipments of pellets from this plant totaled 1.4 million tons in 1976.

Altos Hornos de Mexico S.A. was reported to be investing about $11 million to expand production facilities for iron ore at the La Perla deposits in Chihuahua.

Philippines.—Mining of iron-bearing beach sands was suspended by the Government in mid-1976, pending submission of plans by the mining companies for restoration of mined areas. Production and exports of iron concentrates in 1976 consequently declined by more than 50% from 1975 levels. Only two companies — Inco Mining Co. and Filmag (Philippines) Inc. — were producing iron concentrates in 1976.

South Africa, Republic of.—Production and exports of iron ore in 1976 increased sharply, compared with those of 1975. The gains were mainly generated by increased production of hematite ore at the Sishen mine and the beginning of exports from Saldanha Bay. The 530-mile Sishen-Saldanha railroad was completed in May, and export shipments began in late September. Fourteen shiploads were dispatched by yearend. The shipping port is about 71 miles north of Capetown.

The initial contract between South African Iron & Steel Industrial Corp. Ltd. (ISCOR) and Japanese buyers for ore shipments from Saldanha Bay called for 2 million tons during fiscal year 1976 (year ending March 31, 1977). Contract prices (f.o.b., per dry metric ton) were $14.77 for lump ore (64% to 66% Fe) and $11.61 for fines (63% to 65% Fe). Expected ratio of lump to fines was about 2:1.

Swaziland.—Shipments of iron ore from Ngwenya by the Swaziland Iron Ore Development Corp. totaled 1.7 million tons in 1976. Production was expected to cease by the end of 1977 owing to exhaustion of ore reserves, although shipping of fines from stockpiles may continue for another 2 years.

Sweden.—Swedish production and exports declined slightly in 1976. Production by Luossavaara-Kiirunavaara AB (LKAB) totaled 24.2 million tons, about 3.5% less than in 1975, while output by Gränges AB declined about 13% to 2.4 million tons. Shipments of ore by Stora Kopparbergs Bergslags AB, destined for the domestic market, declined by 10% to 1.2 million tons.

Weak demand for Swedish ore in the European market led to lower prices in 1976, particularly for high-phosphorus ore. LKAB reported a 5% reduction in price of low-phosphorus ore for 1977, and further reductions for high-phosphorus grades. Both LKAB and Gränges reported heavy increases in ore stocks in 1976. Ore stockpiled by LKAB increased 32% during the year, to 12.4 million tons including 2.2 million tons stockpiled at continental ports. Gränges AB, faced with increasing competition from foreign ores, decided there was little likelihood of maintaining profitable exports from underground mines in central Sweden and planned a permanent reduction in output at Grängesberg. About 300 employees will be affected.

A $17 million flotation plant began production of low-phosphorus concentrate at Grängesberg in 1976. At Narvik, Norway, LKAB continued to expand its shipping facilities. Installation of a new quay and shiploader capable of accommodating vessels of up to 350,000 deadweight tons was scheduled for completion in mid-1977.

Turkey.—A pellet plant with production capacity of about 4.3 million tons per year is to be built at Divrigi in central Turkey. The Turkish Iron & Steel Works Co. contracted with the West German firm of Thyssen-Rheinstal Technik G.m.b.H. to supply the plant, which will use the Allis-Chalmers grate kiln and heat-recuperation systems.

U.S.S.R.—Production of crude iron ore in 1976 was estimated at about 490 million tons, from which 235 million tons of usable ore was obtained. Output of usable ore consisted 82% of concentrates and 18% of direct-shipping ore. Average iron content of usable ore produced was 59.3%. Production of pellets was estimated at 30 million tons, compared with 27 million tons in 1975. Production plans called for output of 60 million tons of pellets in 1980.

The Lebedinskiy iron ore mining and concentrating complex in the Belgorod region of the Kursk Magnetic Anomaly was reportedly completed in 1976. Annual production capacity was 30 million tons of crude ore and an estimated 12 million tons of ore products including 4 million tons of pellets. In the same area, a pelletizing plant with a production capacity of 3 million tons per year was reportedly completed at the Mikhaylovskiy complex. At Kremenchug in the Ukraine, construction of a 6-million-ton-per-year pelletizing plant was nearly completed, and another plant of the same capacity was reportedly under construction.

Venezuela.—Production and exports of iron ore declined by more than 20% in 1976, largely because of reduced demand for Venezuelan ore in the United States. Exports to the United States in 1976 were 4 million tons less than in 1975. Of the 15.9 million tons exported in 1976, 57% was destined for the United States, 37% was destined for Common Market countries, and most of the remainder was destined for Spain.

Ferrominera Orinoco C.A., a subsidiary of the Government-owned Corporacion Venezolana de Guayana, assumed exclusive responsibility for development of the iron ore industry on January 1, 1976. Operations were conducted under two divisions; the Piar division, which includes the mine at Cerro Bolivar and the ore-drying and screening plant and shipping facilities at Puerto Ordaz; and the Pao division, which includes the mine at El Pao and the washing plant and shipping facilities at Palua. The Piar division accounted for 83% of Venezuelan production and exports of iron ore in 1976; this included 1.1 million tons of ore produced at San Isidro for consumption by Siderurgica del Orinoco (SIDOR) at Matanzas.

Production of partly reduced ore (high-iron briquets) at Puerto Ordaz totaled 171,000 tons in 1976, compared with 203,000 tons in 1975. At Matanzas, the direct-reduction plant of Fior de Venezuela was completed in 1976. Two other direct-reduction plants were under construction at Ciudad Guayana.

A pelletizing plant designed to produce 6.5 million tons of iron ore pellets per year was under construction by Voest-Alpine AG for SIDOR in 1976. The plant will employ the Lurgi traveling-grate system and was scheduled for completion in 1978.

In December 1976, Ferrominera Orinoco awarded a contract to the Link-Belt division of FMC Corp. to expand production capacity of the ore-drying and screening plant at Puerto Ordaz. The plant's production capacity for dried ore fines will be doubled to approximately 14 million tons per year.

TECHNOLOGY

Increasing costs of materials, labor, fuels, and environmental controls continued to plague the iron mining industry in 1976. To minimize this, companies attempted to improve operating methods and to devise better cost controls. In the 10-year period 1965-75, equipment costs increased 84%, material costs increased 100%, and labor costs increased 133%.[4]

In the iron ore industry, several companies, to control costs, have reversed the trend of increasing the size of mining equipment. Reserve Mining Co. chose to continue using 100-ton trucks as well as jet-piercer drills. Likewise, Eveleth Taconite Co., for its expansion completed in 1976, purchased 85-ton trucks[5] and four 195-B electric shovels with 10-cubic-yard buckets, rather than the 150- to 350-ton trucks or the 16- to 20-cubic-yard shovels available on the market. The main reasons for using the smaller equipment were lower initial cost and higher operating availability.

Processing, on the other hand, was tending toward larger machinery. A 10-foot-diameter cone crusher for milling operations was placed in service in the Republic of South Africa, and flotation cells with volumes of more than 600 cubic feet were planned. Larger ball and rod mills were being used, as evidenced by those installed by Eveleth Taconite Co. Semiautogenous grinding was increasingly favored. The use of rubber liners in ball mills was rising because of the ease of installation, longer life, and acid-resisting characteristics.[6]

Process control was also becoming more sophisticated. Two methods were being adapted to iron ore beneficiation: Radioisotope probes in the process stream; and the ability to measure particle sizes within the stream. By using the probes, metal concentration data, essential for control, may be obtained rapidly and precisely.

A new dock facility of the Burlington Northern Railroad at Superior, Wis., capable of handling 18 million tons of pellets per year, was being built to handle the production of the Hibbing Taconite Co. and the National Steel Pellet Co. Completion of the facility was expected in early 1977.[7]

A further technological development was the increasing number of plants utilizing direct-reduction processes. Three Midrex plants added capacity or began operations during 1976: The Dalmine Siderca plant in Argentina; the Siderurgica del Orinoco C.A. plant in Venezuela; and the Sidbec-Dosco, Ltd., plant in Quebec. Predictions were that by 1980, direct-reduction plants will be providing 15 million tons per year of direct-reduced iron.[8]

The Bureau of Mines Twin Cities Metallurgy Research Center continued to investigate concentration of Western Mesabi nonmagnetic taconites by cationic flotation. Completion of these tests was not expected until 1978. The center also conducted tests in metallizing pelletized iron oxide concentrates, using lignite and coal in a rotary kiln. The tests proved that this can be done successfully.[9]

Environmental research, in reclaiming both previously mined areas and areas being mined, was being conducted by the Bureau of Mines, as well as by industry. The Bureau's research included the design of new equipment and the development of new methods for backfilling old and new workings.

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[4]Mining Congress Journal. A Glimpse at Open Pit Mining in 1976. V. 63, No. 2, February 1977, pp. 117-127.

[5]Skillings' Mining Review. Eveleth Expansion Marks Start Up of New Plant Capacity. V. 66, No. 2, Jan. 8, 1977, pp. 48-49.

[6]Allen, P. Minerals Processing — 1976. Min. Cong. J., v. 63, No. 2, February 1977.

[7]Skillings' Mining Review. V. 66, No. 30, July 23, 1977, pp. 10-11.

[8]Engineering and Mining Journal. Three New Midrex Reduction Plants Go Onstream. V. 178, No. 5, May 1977, pp. 37-40.

[9]Peterson, R. E., and C. Prasky. Metallization of Pelletized Domestic Iron Oxide Superconcentrates With Lignite and Coal In a Rotary Kiln. BuMines RI 8179, 1976, 18 pp.

Table 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced, and average output per man in 1976, by district and State

District and State	Average number of men employed (thousands)	Man-hours (thousands)	Crude ore (thousand long tons)	Usable ore (thousand long tons)	Iron contained[1] (thousand long tons)	Iron content (natural, percent)	Average per man-hour: Crude ore (long tons)	Average per man-hour: Usable ore (long tons)	Average per man-hour: Iron contained (long tons)
Lake Superior:									
Michigan	4	8,081	43,959	16,980	10,759	63.4	5.44	2.10	1.33
Minnesota	12	22,321	148,689	49,764	30,528	61.4	6.66	2.23	1.37
Wisconsin	([2])	463	2,253	668	432	64.7	4.87	1.44	.93
Total or average[1]	16	30,865	194,901	67,413	41,719	61.9	6.31	2.18	1.35
Other States[3]	5	8,308	29,162	11,869	7,194	60.6	3.51	1.43	.87
Grand total or average[1] [4]	20	39,173	224,063	79,282	48,913	61.7	5.72	2.02	1.25

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Includes Arizona, California, Colorado, Georgia, Missouri, Montana, Nevada, South Dakota, Texas, Utah, and Wyoming.
[4]Excludes byproduct ore.

Table 3.—Crude iron ore mined in the United States, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	1975 Number of mines	1975 Hematite	1975 Limonite	1975 Magnetite	1975 Total quantity[1]	1976 Number of mines	1976 Hematite	1976 Limonite	1976 Magnetite	1976 Total quantity[1]
Lake Superior:										
Michigan	6	W	--	W	39,788	6	W	--	W	43,959
Minnesota	30	20,029	--	123,267	143,296	32	18,422	--	130,268	148,689
Wisconsin	1	--	--	2,285	2,285	1	--	--	2,253	2,253
Total reportable	37	20,029	--	125,552	185,369	39	18,422	--	132,521	194,901
Southeastern States: Alabama and Georgia	3	--	384	--	384	2	--	W	--	W
Northeastern States: New York and Pennsylvania	3	--	--	5,171	5,171	3	--	--	5,540	5,540
Western States:										
Missouri	2	--	--	4,174	4,174	2	--	--	4,081	4,081
Montana	2	--	--	18	18	2	--	--	18	18
Nevada	3	W	--	W	106	2	W	--	W	W
Utah	4	W	--	W	3,544	3	--	--	3,433	3,433
Wyoming	2	W	--	W	5,070	2	W	--	W	4,993
Other[2]	11	109	2,323	8,254	10,686	9	81	W	8,463	10,791
Total reportable	24	109	2,323	12,446	23,598	20	81	W	15,995	23,316
Total withheld	--	20,920	--	27,588	([3])	--	22,097	2,423	26,984	305
Grand total[1]	67	41,058	2,707	170,757	214,522	64	40,599	2,423	181,041	224,063

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld" and "Total quantity."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes Arizona, California, Colorado, Idaho, New Mexico, South Dakota, and Texas in 1975. Includes Arizona, California, Colorado, South Dakota, and Texas in 1976.
[3]Total withheld data included with "Total quantity" for each respective district or State.

Table 4.—Crude iron ore mined in the United States, by district, State, and mining method

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	1975 Open pit	1975 Underground	1975 Total quantity[1]	1976 Open pit	1976 Underground	1976 Total quantity[1]
Lake Superior:						
Michigan	37,746	2,042	39,788	41,993	1,966	43,959
Minnesota	143,296	--	143,296	148,689	--	148,689
Wisconsin	2,285	--	2,285	2,253	--	2,253
Total reportable	183,327	2,042	185,369	192,935	1,966	194,901
Southeastern States: Alabama and Georgia	384	--	384	W	--	W
Northeastern States: New York and Pennsylvania	W	W	5,171	W	W	5,540
Western States:						
Missouri	--	4,174	4,174	--	4,081	4,081
Montana	18	--	18	18	--	18
Nevada	106	--	106	W	--	W
Utah	3,544	--	3,544	3,433	--	3,433
Wyoming	W	W	5,070	W	W	4,993
Other[2]	10,686	--	10,686	10,791	--	10,791
Total reportable[1]	14,354	4,174	23,598	14,242	4,081	23,316
Total withheld	7,677	2,564	([3])	8,277	2,561	305
Grand total[1]	205,743	8,779	214,522	215,455	8,608	224,063

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld" and "Total quantity."

[1]Data may not add to totals shown because of independent rounding.

[2]Includes Arizona, California, Colorado, Idaho, New Mexico, South Dakota, and Texas in 1975. Includes Arizona, California, Colorado, South Dakota, and Texas in 1976.

[3]Total withheld data included with "Total quantity" for each respective district or State.

Table 5.—Crude iron ore shipped from mines in the United States, by district, State, and disposition

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	1975 Direct to consumers	1975 To beneficiating plants	1975 Total quantity[1]	1976 Direct to consumers	1976 To beneficiating plants	1976 Total quantity[1]
Lake Superior:						
Michigan	348	174,922	39,600	360	192,682	44,089
Minnesota			135,670			148,953
Wisconsin	--	2,285	2,285	--	2,253	2,253
Total reportable[1]	348	177,207	177,555	360	194,935	195,296
Southeastern States: Alabama and Georgia	--	384	384	--	W	W
Northeastern States: New York and Pennsylvania	--	4,328	4,328	--	5,633	5,633
Western States:						
Missouri	--	4,195	4,195	--	4,063	4,063
Montana	18	--	18	18	--	18
Nevada	106	--	106	W	--	W
Utah	W	W	3,535	W	W	3,440
Wyoming	W	W	5,070	--	4,993	4,993
Other[2]	274	10,757	11,031	444	10,088	10,532
Total reportable	398	14,952	23,956	462	19,144	23,046
Total withheld	998	7,608	([3])	1,026	2,719	305
Grand total[1]	1,745	204,478	206,223	1,849	222,432	224,281

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld" and "Total quantity."

[1]Data may not add to totals shown because of independent rounding.

[2]Includes Arizona, California, Colorado, Idaho, New Mexico, South Dakota, and Texas in 1975. Includes Arizona, California, Colorado, South Dakota, and Texas in 1976.

[3]Total withheld data included with "Total quantity" for each respective district or State.

Table 6.—Usable iron ore produced in the United States, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	1975 Hematite	1975 Limonite	1975 Magnetite	1975 Total quantity[1]	1976 Hematite	1976 Limonite	1976 Magnetite	1976 Total quantity[1]
Lake Superior:								
Michigan	W	--	W	14,774	W	--	W	16,980
Minnesota	10,466	--	40,711	51,177	9,120	--	40,644	49,764
Wisconsin	--	--	784	784	--	--	668	668
Total reportable[1]	10,466	--	41,495	66,735	9,120	--	41,312	67,413
Southeastern States: Alabama and Georgia	--	139	--	139	--	W	--	W
Northeastern States: New York and Pennsylvania	--	--	1,860	1,860	--	--	2,017	2,017
Western States:								
Missouri	--	--	2,299	2,299	--	--	2,204	2,204
Montana	--	--	18	18	--	--	18	18
Nevada	W	--	W	106	W	--	W	W
Utah	W	--	W	1,331	--	--	1,334	1,334
Wyoming	W	--	W	2,039	W	--	W	2,139
Other[2]	109	600	3,142	3,850	W	W	W	3,971
Total reportable	109	600	5,459	9,643	W	W	3,556	9,666
Total withheld	8,670	--	9,581	(3)	10,228	639	12,409	187
Total all States[1]	19,244	739	58,395	78,378	19,348	639	59,295	79,282
Byproduct ore[4]	--	--	--	487	--	--	--	711
Grand total[1]	19,244	739	58,395	78,866	19,348	639	59,295	79,993

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes Arizona, California, Colorado, Idaho, New Mexico, South Dakota, and Texas in 1975. Includes Arizona, California, Colorado, South Dakota, and Texas in 1976.
[3]Total withheld data included with "Total quantity" for each respective district or State.
[4]Including magnetite and residues from iron sulfides produced from base metal mines.

Table 7.—Usable iron ore produced in the United States, by district, State, and type of product

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	1975				1976			
	Direct-shipping ore	Agglomerates	Concentrates	Iron content (natural, percent)	Direct-shipping ore	Agglomerates	Concentrates	Iron content (natural, percent)
Lake Superior:								
Michigan	386	14,287	10,566	63	330	16,553	9,249	63
Minnesota		40,711		61		40,612		61
Wisconsin	--	784	--	65		668		65
Total reportable	386	55,782	10,566	61	330	57,833	9,249	62
Southeastern States: Alabama and Georgia	--	--	139	47	--	--	W	53
Northeastern States: New York and Pennsylvania	--	W	W	64	--	W	W	63
Western States:								
Missouri	--	2,269	30	67	--	2,160	44	66
Montana	18	--	--	50	18	--	--	46
Nevada	106	--	--	60	W	--	--	60
Utah	W	--	W	57	W	--	W	54
Wyoming	W	W	W	61	--	W	W	59
Other[1]	274	W	W	59	444	W	W	59
Total reportable	398	2,269	30	66	462	2,160	44	60
Total withheld	998	5,066	2,744	60	1,026	4,541	3,636	63
Total all States[2]	1,783	63,117	13,480	61	1,819	64,534	12,929	62
Byproduct ore[3]	--	[4]487	--	63	--	[4]711	--	63
Grand total	1,783	[r]63,604	[r]13,480	61	1,819	65,245	12,929	62

[r]Revised. W Withheld to avoid disclosing individual company confidential data; included with "Total withheld."
[1]Includes Arizona, California, Colorado, Idaho, New Mexico, South Dakota, and Texas in 1975. Includes Arizona, California, Colorado, South Dakota, and Texas in 1976.
[2]Data may not add to totals shown because of independent rounding.
[3]Including magnetite and residues from iron sulfides produced from base metal mines.
[4]Byproduct concentrates included with agglomerates to avoid disclosing individual company confidential data.

Table 8.—Shipments of usable iron ore from mines in the United States in 1976

(Thousand long tons and thousand dollars exclusive of ore containing 5% or more manganese)

District and State	Gross weight of ore shipped: Direct-shipping ore	Gross weight of ore shipped: Agglom-erates	Gross weight of ore shipped: Concen-trates	Gross weight of ore shipped: Total quantity[1]	Iron content of ore shipped: Direct-shipping ore	Iron content of ore shipped: Agglom-erates	Iron content of ore shipped: Concen-trates	Iron content of ore shipped: Total quantity[1]	Total value[1]
Lake Superior:									
Michigan	360	15,789	8,902	16,245	198	10,001	4,847	10,250	441,206
Minnesota		39,068		47,874		24,506		29,302	1,137,733
Wisconsin	--	664	--	664	--	429	--	429	W
Total reportable[1]	360	55,521	8,902	64,783	198	34,936	4,847	39,981	1,578,939
Southeastern: Georgia	--	--	W	W	--	--	W	W	W
Northeastern States: New York and Pennsylvania	--	W	W	2,136	--	W	W	1,339	W
Western States:									
Missouri	--	2,090	44	2,133	--	1,386	29	1,415	W
Montana	18	--	--	18	8	--	--	8	W
Nevada	W	--	W	W	W	--	W	W	W
Utah	W	--	W	1,260	W	--	W	686	W
Wyoming	--	W	W	2,139	--	W	W	1,267	29,461
Other[2]	573	W	W	4,041	356	W	W	2,334	98,724
Total reportable[1]	591	2,090	44	9,591	365	1,386	29	5,710	128,185
Total withheld	897	4,606	3,686	187	484	2,848	2,045	108	152,978
Total all States[1]	1,849	62,217	12,631	76,697	1,048	39,170	6,921	47,139	1,860,102
Byproduct ore[3]	--	[4]379	--	379	--	[4]240	--	239	11,012
Grand total[1]	1,849	62,596	12,631	77,076	1,048	39,410	6,921	47,378	1,871,114

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes Arizona, California, Colorado, Idaho, New Mexico, South Dakota, and Texas in 1975. Includes Arizona, California, Colorado, South Dakota, and Texas in 1976.
[3]Including magnetite and residues from iron sulfides produced from base metal mines.
[4]Includes small quantities of concentrates.

Table 9.—Usable iron ore produced in Lake Superior district, by range

(Thousand long tons and exclusive after 1905 of ore containing 5% or more manganese)

Year	Marquette	Menominee	Gogebic	Vermilion	Mesabi	Cuyuna	Spring Valley	Black River Falls	Total[1]
1854-1971	399,593	308,462	320,334	103,528	2,827,809	70,336	8,149	1,676	4,039,885
1972	9,131	2,533	--	--	48,998	--	--	888	61,550
1973	9,036	2,404	--	--	60,021	--	--	956	72,416
1974	8,920	2,419	--	--	58,484	--	--	899	70,723
1975	12,443	2,331	--	--	51,177	--	--	784	66,735
1976	14,663	2,318	--	--	49,764	--	--	668	67,413
Total	453,786	320,467	320,334	103,528	3,096,253	70,336	8,149	5,871	4,378,722

[1]Data may not add to totals shown because of independent rounding.

Table 10.—Average analyses of total tonnage[1] of all grades of iron ore shipped from the U.S. Lake Superior district

Year	Quantity (thousand long tons)	Content (percent)[2]					
		Iron	Phosphorus	Silica	Manganese	Alumina	Moisture
1972	64,721	60.40	0.031	6.76	0.30	0.52	3.93
1973	76,281	60.66	.030	6.77	.33	.41	3.79
1974	72,194	60.26	.030	6.68	.35	.40	3.94
1975	64,174	60.91	.030	6.72	.28	.39	3.53
1976	64,928	61.38	.029	6.72	.26	.43	3.20

[1]Railroad weight—gross tons.
[2]Iron and moisture on natural basis; phosphorus, silica, manganese, and alumina on dried basis.

Source: American Iron Ore Association. Iron Ore, 1975, p. 92; 1976, p. 94.

Table 11.—Consumption of iron ore and agglomerates in the United States in 1976

(Thousand long tons and exclusive of ore containing 5% or more manganese)

State	Iron ore and concentrates[1]		Agglomerates[2]		Miscellaneous[3]	Total reportable
	Blast furnaces	Steel furnaces	Blast furnaces	Steel furnaces		
Alabama, Kentucky, Texas	1,852	13	7,031	W	W	8,896
California, Colorado, Utah	1,451	W	5,565	W	W	7,016
Ohio and West Virginia	3,810	153	21,599	132	W	25,694
Illinois and Indiana	1,134	--	32,691	99	W	33,924
Michigan	213	--	9,734	W	W	9,947
Maryland, New York, Pennsylvania	6,345	325	31,830	441	W	38,941
Undistributed	--	97	--	23	885	1,005
Total[4]	14,805	588	108,450	696	885	125,424

W Withheld to avoid disclosing individual company confidential data; included in "Undistributed."
[1]Not including pellets or other agglomerated products.
[2]Includes 62,225,569 tons of pellets produced at U.S. mines and 13,226,321 tons of foreign pellets and other agglomerates.
[3]Includes iron ore consumed in production of cement and ferroalloys, and iron ore shipped for use in manufacture of paint, ferrites, and heavy media.
[4]Data may not add to totals shown because of independent rounding.

Table 12.—Iron ore consumed in production of agglomerates at iron and steel plants in 1976, by State

(Thousand long tons)

State	Iron ore consumed[1]	Agglomerates produced
Alabama, Kentucky, Texas	2,520	3,442
California, Colorado, Utah	1,895	2,068
Ohio and West Virginia	2,330	3,496
Illinois, Indiana, Michigan	6,599	9,789
Maryland, New York, Pennsylvania	10,135	13,931
Total	23,479	32,726

[1]Includes domestic and foreign ores.

Table 13.—Beneficiated iron ore shipped from mines in the United States[1]

(Thousand long tons and exclusive of ore containing 5% or more manganese)

Year	Beneficiated ore	Total iron ore	Proportion of beneficiated to total (percent)
1972	72,011	77,884	92.5
1973	86,894	90,654	95.9
1974	79,995	84,985	94.1
1975	73,951	75,695	97.7
1976	74,848	76,697	97.6

[1]Beneficiated by further treatment than ordinary crushing and screening. Excludes byproduct ore.

Table 14.—Production of iron ore agglomerates[1] in the United States, by type

(Thousand long tons)

Type	Agglomerates produced	
	1975	1976
Sinter, nodules, cinder	[2]30,825	[3]32,955
Pellets	62,779	64,305
Total	93,604	97,260

[1]Production at mines and consuming plants.
[2]Includes 14,942,000 tons of self-fluxing sinter.
[3]Includes 16,318,600 tons of self-fluxing sinter.

Table 15.—Stocks of usable iron ore at mines,[1] Dec. 31, by district

(Thousand long tons)

District	1975	1976
Lake Superior	5,851	7,954
Southeastern States	612	--
Northeastern States	5,191	5,057
Western States	646	982
Total	[2]12,299	13,993

[1]Excluding byproduct ore.
[2]Data do not add to total shown because of independent rounding.

Table 16.—Average value of usable iron ore[1] shipped from mines or beneficiating plants in the United States in 1976

(Dollars per long ton)

Type of ore	District			
	Lake Superior	Southeastern	Northeastern	Western
Direct-shipping, hematite and magnetite	13.26	--	--	9.46
Concentrates, hematite and magnetite	13.32	--	18.00	17.35
Concentrates, limonite	--	W	--	18.74
Agglomerates	26.56	--	W	26.54

W Withheld to avoid disclosing individual company confidential data.
[1]F.o.b. mine or plant. Excludes byproduct ore.

Table 17.—U.S. exports of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
Austria	--	--	5	132	--	--
Canada	1,814	30,061	2,485	59,170	2,897	80,981
France	27	329	6	78	11	1,129
Japan	439	4,691	40	658	(1)	2
Mexico	1	14	1	12	(1)	5
Sweden	40	20	--	--	--	--
United Kingdom	--	--	(1)	3	5	32
Other	2	33	(1)	18	(1)	43
Total	2,323	35,148	2,537	60,071	2,913	82,192

[1]Less than 1/2 unit.

Table 18.—U.S. imports for consumption of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
Africa, Western, n.e.c	8	90	112	1,702	--	--
Angola	r260	r3,312	213	4,961	--	--
Australia	638	7,292	803	8,512	616	12,384
Brazil	6,572	85,259	7,525	120,947	5,388	111,797
British West Africa	38	365	--	--	--	--
Canada	19,702	341,577	19,111	420,116	24,962	625,588
Chile	296	2,883	932	12,172	608	7,962
Gabon	57	577	--	--	--	--
Germany, West	16	590	--	--	--	--
India	--	--	164	1,661	130	1,198
Italy	--	--	--	--	3	103
Japan	--	--	56	1,024	--	--
Liberia	2,730	r29,113	2,496	38,909	2,152	34,198
Morocco	--	--	--	--	11	259
New Guinea	48	470	--	--	--	--
Norway	--	--	53	1,285	151	4,949
Peru	1,810	r27,325	1,551	32,627	716	15,233
Philippines	15	392	14	478	4	170
South Africa, Republic of	1	21	129	2,475	162	4,979
Sweden	335	6,215	182	5,783	442	9,412
U.S.S.R	126	1,622	265	2,518	44	471
Venezuela	r15,377	189,188	13,137	205,304	9,001	151,635
Other	(1)	7	(1)	22	(1)	10
Total	48,029	696,298	46,743	860,496	44,390	980,348

rRevised.
[1]Less than 1/2 unit.

Table 19.—U.S. imports for consumption of iron ore, by customs district

(Thousand long tons and thousand dollars)

Customs district	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
Baltimore	11,880	153,554	10,832	181,979	9,279	197,218
Buffalo	4,294	81,557	2,759	62,775	3,471	93,307
Charleston	70	790	154	4,076	190	5,043
Chicago	3,999	65,179	4,026	82,517	6,037	137,956
Cleveland	4,857	82,728	5,556	116,315	7,736	193,430
Detroit	1,428	28,034	1,899	45,556	1,881	53,891
Houston	925	16,844	690	14,938	153	3,228
Los Angeles	134	1,396	56	803	150	2,707
Mobile	5,776	73,414	4,265	70,764	4,627	91,364
New Orleans	677	8,762	624	10,344	809	14,237
Philadelphia	13,364	173,894	15,274	256,820	9,597	176,787
Portland, Oreg	270	3,074	310	5,407	198	3,451
Seattle	--	--	(1)	(1)	34	809
San Juan	5	45	--	--	--	--
Wilmington, N.C	346	6,626	296	8,084	226	6,798
Other	4	401	2	118	2	122
Total	48,029	696,298	46,743	860,496	44,390	980,348

[1]Less than 1/2 unit.

Table 20.—Iron ore, iron ore concentrates, and iron ore agglomerates: World production by country

(Thousand long tons)

Country[1]	Gross weight[2]			Metal content[3]		
	1974	1975	1976[p]	1974	1975	1976[p]
North and Central America:						
Canada[4]	49,187	46,128	56,090	30,344	28,724	34,928
Mexico[5]	4,928	4,974	5,380	3,286	3,316	3,587
United States[6]	84,355	78,866	79,993	51,457	48,266	49,362
South America:						
Argentina	[r]408	260	[e]345	[r]209	119	[e]157
Bolivia (exports)	--	31	--	--	19	--
Brazil	[r]74,309	88,474	[e]90,360	[r]48,301	57,508	[e]59,640
Chile	10,109	10,875	10,225	6,369	6,851	6,255
Colombia	437	529	[e]540	188	227	[e]233
Peru	9,375	7,630	4,701	[r]6,121	4,987	3,040
Venezuela	26,007	24,381	[e]17,910	[r]16,124	15,116	[e]11,110
Europe:						
Albania[e 7]	395	415	420	140	145	150
Austria	4,178	3,772	3,724	1,290	1,182	1,147
Belgium	121	92	62	36	28	19
Bulgaria	[r]2,643	2,300	2,279	845	736	752
Czechoslovakia	1,661	1,745	1,878	498	523	488
Denmark	6	13	[e]13	2	5	[e]5
Finland[8]	922	894	1,149	605	587	756
France	[r]53,403	48,863	44,468	[r]16,450	15,067	13,573
Germany, East[9]	[r]52	58	50	[r]20	23	19
Germany, West (salable)	4,369	3,236	2,220	1,390	1,036	738
Hungary	536	632	592	126	151	141
Italy[10]	584	532	506	257	234	253
Luxembourg	2,644	2,279	2,046	793	684	593
Norway	3,842	4,044	3,859	2,485	2,620	2,500
Poland	1,276	1,173	668	383	352	200
Portugal[11]	[r]52	55	47	[r]21	22	27
Romania	3,213	3,017	2,790	1,044	980	725
Spain	8,108	7,520	7,488	3,926	3,634	3,742
Sweden	35,582	30,379	30,046	22,495	19,332	19,109
U.S.S.R	[r]221,252	229,126	235,225	[r]130,539	135,185	138,783
United Kingdom	3,545	4,419	4,500	934	1,162	1,183
Yugoslavia	4,954	5,156	4,193	[r]1,777	1,898	1,543
Africa:						
Algeria	3,732	3,149	2,756	2,016	1,703	1,486
Angola	5,413	[r e]2,706	(12)	[r e]3,275	[r e]1,638	(12)
Egypt	[r]1,016	1,103	1,223	[r]508	551	612
Kenya[13]	19	16	[e]16	[e]12	[e]9	[e]9
Liberia	23,409	23,620	18,517	14,280	14,710	11,943
Mauritania	11,482	8,549	9,511	7,233	5,514	6,135

See footnotes at end of table.

Table 20.—Iron ore, iron ore concentrates, and iron ore agglomerates: World production by country —Continued

(Thousand long tons)

Country[1]	Gross weight[2]			Metal content[3]		
	1974	1975	1976[p]	1974	1975	1976[p]
Africa: —Continued						
Morocco	523	545	337	324	344	213
Rhodesia, Southern[e]	[r]590	590	590	[r]378	378	378
Sierra Leone	1,982	1,431	--	1,249	901	--
South Africa, Republic of[14]	11,370	12,104	15,416	7,107	7,565	9,635
Swaziland	2,044	2,204	[15]1,717	1,288	1,389	1,082
Tunisia	805	601	504	[r]477	331	253
Asia:						
China, People's Republic of[e]	[r]60,000	64,000	64,000	[r]30,000	32,000	32,000
Hong Kong	157	165	36	83	87	18
India	34,925	40,645	42,336	21,863	25,444	26,502
Indonesia	[r]359	347	288	208	202	161
Iran[16]	[r]985	985	1,085	600	600	660
Japan[17]	766	715	746	436	417	443
Korea, North	9,250	9,250	9,350	3,700	3,700	3,740
Korea, Republic of	485	516	612	272	288	343
Malaysia	466	343	303	261	209	185
Philippines	1,583	1,330	562	910	799	315
Taiwan	([12])	([12])	--	([12])	([12])	--
Thailand	36	32	25	21	19	15
Turkey	2,249	2,203	3,391	[r]1,293	1,267	1,950
Oceania:						
Australia	[r]95,419	96,111	91,775	60,308	60,771	57,761
New Zealand[18]	2,316	2,261	[e]2,165	1,320	1,289	[e]1,235
Total	[r]883,834	887,389	881,028	[r]507,877	512,844	511,832

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, Cuba and Vietnam may produce iron ore, but definitive information on output levels, if any, is not available.

[2]Insofar as availability of sources permits, gross weight data in this table represent the nonduplicative sum of marketable direct shipping iron ores, iron ore concentrates, and iron ore agglomerates produced by each of the listed countries. Concentrates and agglomerates produced from imported iron ores have been excluded, under the assumption that the ore from which such materials are produced has been credited as marketable ore in the country where it was mined.

[3]Data represent actual reported weight of contained metal or are calculated from reported metal content. Estimated figures are based on latest available iron ore content reported, except for the following countries from which grades are U.S. Bureau of Mines estimates: Albania, Denmark, Hungary, Southern Rhodesia, the People's Republic of China, and North Korea.

[4]Gross weight and metal content of shipments of usable iron ore, including byproduct ore, dry tons.

[5]Gross weight calculated from reported iron content based on grade of 66.67% Fe.

[6]Includes byproduct ore.

[7]Nickeliferous iron ore.

[8]Includes magnetite concentrate, pelletized iron oxide (from pyrite sinter) and roasted pyrite (purple ore).

[9]Includes "roasted ore," presumably pyrite sinter, not separable from available sources.

[10]Excludes iron oxide pellets produced from pyrite sinter.

[11]Includes manganiferous iron ore.

[12]Revised to zero.

[13]For cement manufacture.

[14]Includes byproduct magnetite as follows in long tons: 1974—2,859,303; 1975—[r]2,058,294; 1976—4,244,236.

[15]Sales.

[16]Year beginning March 21 of that stated.

[17]Concentrate including concentrate derived from iron sand as follows in long tons: 1974—232,432; 1975—[r]179,166; 1976— 191,189.

[18]Largely concentrates from magnetite-titanium sands.

Table 21.—Major world trade in iron ores, concentrates, and agglomerates (excluding roasted pyrite)[1] in 1975

(Thousand long tons)

Source country	Recorded total 1975 exports of source country[3]	Recorded imports of principal recipient country[2]: Canada	United States	Belgium-Luxembourg	Czechoslovakia[4]	France	Germany, West	Hungary	Italy
Algeria	1,476	--	--	--	244	12	90	--	50
Angola	[5]2,706	--	213	--	(4)	395	592	--	--
Australia	[6]79,094	--	803	2,234	(4)	1,649	6,311	--	2,051
Brazil	[7]71,377	679	7,525	1,913	649	3,435	10,850	4	3,045
Canada	35,490	XX	19,111	--	(4)	521	4,001	--	1,961
Chile	9,921	--	932	--	(4)	--	56	--	--
France	15,738	--	--	10,631	(4)	XX	2,583	--	(8)
India	22,436	--	164	--	469	--	966	205	--
Liberia	18,110	(8)	2,496	902	488	1,963	6,098	--	2,786
Malaysia	93	--	--	--	(4)	--	--	--	--
Mauritania	8,536	--	--	906	(4)	2,130	593	--	1,292
Norway	3,104	32	53	--	(4)	--	1,142	--	--
Peru	4,819	--	1,551	--	(4)	437	584	--	--
Philippines	1,301	--	14	--	(4)	--	--	--	--
Sierra Leone	[5]1,431	--	--	--	(4)	--	605	--	--
South Africa, Republic of	[e]3,284	--	129	--	(4)	--	292	--	119
Spain	1,929	--	--	--	(4)	306	865	--	(8)
Swaziland	[6]1,929	--	--	--	(4)	--	--	--	--
Sweden	17,342	126	182	4,841	412	1,620	5,671	--	72
U.S.S.R	42,937	--	265	--	12,029	25	167	3,985	1,659
United States	2,537	3,917	XX	--	(4)	--	--	--	(8)
Venezuela	[6]19,811	--	13,137	--	(4)	417	1,843	--	2,127
Other countries	[9]3,879	14	56	--	(4)	10	310	--	236
Origin unreported	XX	--	112	3,689	277	43	--	--	3
Total	369,280	4,768	46,743	25,116	14,568	12,963	43,619	4,194	15,401

Source country	Recorded imports of principal recipient countries[2]: Netherlands	Poland[4]	Romania[4]	United Kingdom[4]	Other Europe[10]	Japan	Other Asia and Pacific[11]	Other Western Hemisphere[12]	Total of listed imports
Algeria	--	(4)	(4)	--	103	--	--	--	499
Angola	--	(4)	(4)	--	50	1,408	--	--	2,658
Australia	677	(4)	(4)	844	893	62,254	599	1,182	79,497
Brazil	1,741	797	[13]1,426	2,170	3,538	23,089	--	--	60,861
Canada	915	(4)	(4)	3,013	970	3,838	15	294	34,639

Chile	--	(4)	(4)	--	--	7,930	--	--	8,918
France	--	(4)	(4)	--	5	--	--	--	13,219
India	138	569	13 2,368	--	--	16,546	721	--	22,146
Liberia	1,065	(4)	(4)	497	1,110	520	--	--	17,925
Malaysia	--	(4)	(4)	--	--	119	32	--	151
Mauritania	365	(4)	(4)	1,584	630	960	--	--	8,460
Norway	--	482	(4)	1,613	247	--	--	--	3,569
Peru	--	(4)	(4)	208	--	2,689	241	33	5,743
Philippines	--	(4)	(4)	--	--	1,489	2	--	1,505
Sierra Leone	--	(4)	(4)	--	--	893	--	--	1,498
South Africa, Republic of	--	(4)	(4)	67	193	1,675	--	--	2,475
Spain	385	(4)	(4)	148	61	--	--	--	1,765
Swaziland	--	(4)	(4)	--	--	1,698	--	--	1,698
Sweden	1,513	2,214	(4)	2,207	1,309	--	--	(8)	20,167
U.S.S.R	--	10,931	13 6,189	954	5,368	1,223	--	--	42,795
United States	--	(4)	(4)	--	50	(8)	1	17	3,985
Venezuela	319	103	(4)	1,775	927	--	--	--	20,648
Other countries	136	53	(4)	428	102	3,335	39	20	14 4,739
Origin unreported	--	30	724	29	779	--	--	(8)	5,686
Total	7,254	15,179	10,707	15,537	16,335	129,666	1,650	1,546	365,246

XX Not applicable.

[1] Disparities between recorded total exports of source countries and totals of recorded imports of recipient countries from each listed source country are generally due to (1) time lag between shipment and receipt, and (2) the fact that the latter totals are incomplete, representing only the imports of the nations listed in the column heads and in footnotes 9, 10, and 11.

[2] Unless otherwise specified, data are compiled from official import statistics of recipient countries.

[3] Unless otherwise specified, data are from official export statistics of listed source countries.

[4] Official imports statistics for Czechoslovakia, Poland, Romania, and the United Kingdom do not fully distribute total imports by country of origin, and therefore do not clearly indicate whether these nations received shipments from any of the source countries where this footnote has been entered.

[5] Exports not available. Production reported in lieu of exports as all or nearly all of output is exported.

[6] Official mineral statistics publication of the source country rather than official trade returns.

[7] Includes pyrite.

[8] Less than 500 long tons.

[9] Summation of (1) recorded exports of the following countries, with export quantity following country name in thousand long tons: Austria, 1; Belgium-Luxembourg, 3; Bolivia, 20; Denmark, 13; West Germany, 5; Hong Kong, 162; Italy, 12; the Republic of Korea, 61; Mexico, 14; Morocco, 211; the Netherlands, 94; New Zealand, 2,315; Tunisia, 291; Yugoslavia 30; together with (2) apparent exports (as measured by imports of trading partner countries) with apparent export quantity following country name in thousand long tons and trading partner countries listed in parentheses: Indonesia, 278 (Japaneses imports only); North Korea, 200 (Japanese imports only); Mozambique, 169 (Japanese imports only). In addition to the foregoing list of countries, Switzerland recorded iron ore exports of less than 500 tons.

[10] Includes the following countries with recorded total imports of each following the country name in thousand long tons: Austria, 2,537; Bulgaria, 1,660; Denmark, 1; Finland, 1,187; East Germany, 2,773; Greece, 775; Norway, 17; Portugal, 379; Spain, 6,039; Sweden, 314; Switzerland, 44; Yugoslavia, 589.

[11] Includes the following countries with recorded total imports of each following the country name in thousand long tons: Australia, 17; the Republic of Korea, 1,470; Malaysia, less than 1/2 unit; Singapore, 24; Taiwan, 141.

[12] Includes the following countries with recorded total imports of each following the country name in thousand long tons: Argentina, 1,496; Brazil, less than 1/2 unit; Mexico, 33; Venezuela, 17.

[13] Official export statistics of source country.

[14] Includes the following reported source countries with total quantity credited to each following the country name in thousand long tons: Belgium-Luxembourg, 95; Bolivia, 20; Denmark, 9; Finland, 1; East Germany, 20; Greece, 6; Hong Kong, 164; Hungary, 58; Indonesia, 287; Iran, 4; Italy, 9; Japan, 86; North Korea, 200; South Korea, 61; Libya, 57; Morocco, 128; Mozambique, 169; the Netherlands, 350; New Zealand, 2,463; Nigeria, 32; Panama, 114; Portugal, 127; Tunisia, 266; the United Kingdom, 15.

Iron Oxide Pigments

By Cynthia T. Collins[1]

Production and trade in iron oxide pigments made a strong recovery in 1976. This reflected the upturn in demand from the coatings, plastics, and other industries which serve the automotive, heavy equipment, and construction markets. The $64.5 million value of finished iron oxide pigment sales and the $16.6 million value of imports indicated an $81 million market in 1976, compared with the 1975 market of $55 million.

Legislation and Government Programs.—In November the Food and Drug Administration (FDA) permanently listed iron oxide pigments for use in cosmetics, including those intended for use in the area of the eye.[2] The ruling was to become effective on January 3, 1977. The original petition filed in August 1973 requested a permanent listing of iron oxides as additives for use in externally applied cosmetics,[3] and an amendment in March 1976 added the use of iron oxides in all types of cosmetics subject to ingestion.[4] The amendment defines the color additive iron oxides as consisting of any one or any combination of synthetically prepared iron oxides, including the hydrated forms, free from admixture with other substances. The oxides must conform to the following specifications: Arsenic, not more than 3 parts per million; lead, not more than 10 parts per million; and mercury, not more than 3 parts per million.

Table 1.—Salient iron oxide pigments statistics in the United States

		1972	1973	1974	1975	1976
Mine production	short tons	W	W	W	r41,278	63,180
Crude pigments sold or used	do	W	W	W	r38,030	55,980
Value	thousands	$418	$931	$1,429	$1,093	$1,263
Iron oxides from steel plant wastes	short tons	NA	NA	W	19,252	21,403
Value	thousands	NA	NA	W	$1,102	$1,258
Finished pigments sold	short tons	152,412	148,802	147,544	104,840	135,915
Value	thousands	$37,673	$43,514	$60,612	$46,206	$64,506
Exports	short tons	4,268	9,888	9,666	8,780	5,805
Value	thousands	$1,926	$3,101	$3,466	$2,523	$3,353
Imports for consumption	short tons	47,271	51,183	54,215	27,979	50,102
Value	thousands	$8,529	$12,005	$16,367	$9,184	$16,554

rRevised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Production of finished iron oxide pigments, as measured by sales, increased 30% over that of 1975. Finished natural pigment production increased 33%, while synthetic pigment production rose 27%. A 40% increase in value of overall sales reflected a 12% rise in the average unit value of synthetic pigments to nearly 40 cents per pound. Values of finished natural pigments remained unchanged. Average unit value of synthetic pigments was nearly five times greater than that of natural oxides.

[1]Mineral specialist, Division of Ferrous Metals.
[2]Federal Register. Listing of Iron Oxides for Use in Cosmetics. V. 41, No. 231, Nov. 30, 1976, pp. 52445-52446.
[3]———. Notice of Filing of Petition Regarding Color Additives. V. 38, No. 150, Aug. 6, 1973, p. 21200.
[4]———. Amendment of Filing of Petitions for Color Additives. V. 41, No. 231, Mar. 5, 1976, p. 9534.

Shipments of pigments increased in all categories in 1976. In synthetic pigments, shipments of yellow iron oxides increased 40% and combined shipments of blacks and browns increased 34%. In natural pigments, the most significant increase occurred in shipments of black magnetite; eight companies produced this product in 1976, compared with four companies in 1975. Umbers, ocher, and red iron oxides also showed large gains.

Table 2 reflects data compiled from responses by 21 companies to the Bureau of Mines canvass and represents 95% coverage by quantity. All companies reported gains in 1976. One new plant came onstream in 1976. BASF Wyandotte Corp. started production in a new 3-million-pound-per-year capacity plant at Wyandotte, Mich., to produce transparent iron oxide pigments for use in metallic and wood-grain finishes. Indiana General Corp. discontinued production of iron oxides in 1976, reportedly due to unfavorable price competition from increased imports of regenerator oxides.

Domestic production of iron oxides from steel plant wastes increased 11% over that of 1975. Four companies produced iron oxides as a byproduct from steel plant dusts or regenerated pickle liquor. These oxides were used mainly in the manufacture of ferrites.

Production of crude iron oxide pigments increased 53% in 1976. Shipments rose 47% but total values increased only 16%, indicating a drop in average unit value. Crude pigments were produced by the four companies listed at the end of table 3.

Table 4 shows a 22-year analysis of finished iron oxide pigment shipments. The ratio of synthetic pigment shipments to natural pigment shipments has been nearly equal for the last 13 years, following a decade when the ratio was at or near 2:1. Ratios of synthetic to natural pigment values have fluctuated over the same period, reaching a high level of 5.4:1 in 1963, and a low of 2.7:1 in 1971. Figures shown annually in table 2 under "Unspecified" have been apportioned between synthetic and natural, as described in the footnote to table 4.

Table 2.—Finished iron oxide pigments sold by processors in the United States, by kind

Pigment	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Natural:				
Black: Magnetite	(1)	(1)	7,235	$602
Brown:				
Iron oxide[2]	10,545	$2,087	8,252	2,306
Umbers:				
Burnt	3,964	1,506	5,243	2,242
Raw	1,454	542	1,827	768
Red:				
Iron oxide[3]	28,486	2,384	37,227	3,003
Sienna, burnt	632	338	672	401
Yellow:				
Ocher[4]	4,209	472	5,461	539
Sienna, raw	638	305	645	319
Total natural	49,928	7,634	66,567	10,180
Synthetic:				
Brown: Iron oxide[5]	5,730	4,494	7,682	6,305
Red: Iron oxides	20,596	13,927	23,285	18,776
Yellow: Iron oxide	19,303	13,998	27,013	20,886
Total synthetic	45,629	32,419	57,980	45,967
Unspecified including mixtures of natural and synthetic iron oxides	9,283	6,153	11,368	8,359
Grand total	104,840	46,206	135,915	64,506

[1]Included with brown iron oxide.
[2]Includes vandyke brown. In 1975, includes black magnetite.
[3]Includes pyrite cinder.
[4]Includes yellow iron oxide.
[5]Includes synthetic black iron oxide.

Table 3.—Producers of iron oxide pigments in the United States in 1976

Producer	Mailing address	Plant location
Finished pigments:		
BASF Wyandotte Corp	100 Cherry Hill Rd. Parsippany, N.J. 07054	Wyandotte, Mich.
Blue Ridge Talc Co., Inc	Box 39 Henry, Va. 24102	Henry, Va.
Chemalloy Co., Inc	Box 350 Bryn Mawr, Pa. 19101	Bryn Mawr, Pa.
Chemetron Corp., Chemetron Pigments Div.	491 Columbia Ave. Holland, Mich. 49423	Huntington, W. Va.
Cities Service Co., Columbian Div.	Box 5373 Akron, Ohio 44313	St. Louis, Mo., Monmouth Junction, N.J., Trenton, N.J.
Combustion Engineering, Inc., CE Minerals Div.	901 East 8th Ave. King of Prussia, Pa. 19406	Camden, N.J.
DCS Color & Supply Co., Inc	1050 East Bay St. Milwaukee, Wis. 53207	Milwaukee, Wis.
E. I. du Pont de Nemours & Co., Inc.	Pigments Dept. Wilmington, Del. 19898	Newark, N.J.
Ferro Corp., Ottawa Chemical Div.	700 North Wheeling St. Toledo, Ohio 43605	Toledo, Ohio.
Foote Mineral Co	Route 100 Exton, Pa. 19341	Exton, Pa.
Greenback Industries, Inc., Greenback Ferrite Div.	Route 2, Box 63 Greenback, Tenn. 37742	Greenback, Tenn.
Hercules Inc., C&SP Dept	720 Commerce St. Pulaski, Va. 24301	Pulaski, Va.
Hoover Color Corp	Box 218 Hiwassee, Va. 24347	Hiwassee, Va.
Mineral Pigments Corp	7011 Muirkirk Rd. Beltsville, Md. 20705	Beltsville, Md.
New Riverside Ochre Co	Box 387 Cartersville, Ga. 30120	Cartersville, Ga.
Pfizer Inc., Minerals, Pigments & Metals Div.	235 East 42d St. New York, N.Y. 10017	Emeryville, Calif., East St. Louis, Ill., Easton, Pa.
Prince Manufacturing Co	700 Lehigh St. Bowmanstown, Pa. 18030	Quincy, Ill. and Bowmanstown, Pa.
Reichard-Coulston Inc	15 East 26th St. New York, N.Y.10010	Bethlehem, Pa.
George B. Smith Chemical Works, Inc.	1 Center St. Maple Park, Ill. 60151	Maple Park, Ill.
Solomon Grinding Service	Box 1766 Springfield, Ill. 62705	Springfield, Ill.
Sterling Drug, Inc., Hilton-Davis Chemicals Div.	2235 Langdon Farm Rd. Cincinnati, Ohio 45237	Cincinnati, Ohio.
Sterling Drug, Inc., Thomassett Color Div.	120 Lister Ave. Newark, N.J. 07105	Newark, N.J.
Crude pigments:		
Cleveland Cliffs Iron Co., Mather Mine & Pioneer Plant	1460 Union Commerce Bldg. Cleveland, Ohio 44115	Negaunee, Mich.
Hoover Color Corp	Box 218 Hiwassee, Va. 24347	Hiwassee, Va.
Meramec Mining Co	Martin Towers, Room 1836 Bethlehem, Pa. 18016	Sullivan, Mo.
New Riverside Ochre Co	Box 387 Cartersville, Ga. 30120	Cartersville, Ga.

Table 4.—Domestic shipments of finished iron oxide pigments 1955-76, by type [1]

Year	Quantity (short tons)			Ratio, synthetic to natural	Value (thousands)			Ratio, synthetic to natural
	Natural	Synthetic	Total		Natural	Synthetic	Total	
1955	41,156	74,146	115,302	1.80	$3,031	$14,441	$17,472	4.76
1956	43,296	70,565	113,861	1.63	3,091	14,013	17,104	4.53
1957	35,345	69,520	104,865	1.97	2,727	13,678	16,405	5.02
1958	33,182	65,240	98,422	1.97	2,655	13,167	15,822	4.96
1959	41,238	76,366	117,604	1.85	3,185	15,852	19,037	4.98
1960	36,238	69,784	106,022	1.93	2,961	14,987	17,948	5.06
1961	35,457	71,045	106,502	2.00	2,927	15,418	18,345	5.27
1962	37,482	75,483	112,965	2.01	3,220	16,578	19,798	5.15
1963	37,489	81,358	118,847	2.17	3,296	17,839	21,135	5.41
1964	56,060	63,479	119,539	1.13	5,553	17,438	22,991	3.14
1965	65,111	62,429	127,540	0.96	6,101	17,448	23,549	2.86
1966	66,601	64,057	130,658	0.96	6,505	18,336	24,841	2.82
1967	60,121	67,217	127,338	1.12	6,133	20,587	26,720	3.36
1968	59,296	73,087	132,383	1.23	6,623	24,053	30,676	3.63
1969	66,953	75,940	142,893	1.13	7,220	25,069	32,289	3.47
1970	53,124	70,864	123,988	1.33	6,378	21,819	28,197	3.42
1971	60,111	68,197	128,308	1.14	8,416	22,921	31,337	2.72
1972	72,212	80,200	152,412	1.11	9,585	28,088	37,673	2.93
1973	66,283	82,519	148,802	1.25	10,000	33,514	43,514	3.35
1974	67,599	79,945	147,544	1.18	10,667	49,945	60,612	4.68
1975	53,022	51,818	104,840	0.98	8,513	37,693	46,206	4.43
1976	70,356	65,559	135,915	0.93	11,374	53,132	64,506	4.67

[1] Figures for "Natural" and "Synthetic" include those classed as "Mixtures and Other" in table 2. Quantities of "Mixtures and Other" apportioned one-third to "Natural" and two-thirds to "Synthetic"; value of "Mixtures and Other" apportioned one-seventh to "Natural" and six-sevenths to "Synthetic."

CONSUMPTION AND USES

Apparent domestic consumption[5] of 180,212 short tons of iron oxide pigments in 1976 was 45% above the 1975 level of 124,039 tons. Demand from the automotive, industrial, and furniture coatings industries increased strongly in 1976. All color categories of the iron oxides showed marked gains during the year, with a very strong increase in demand for transparent oxides for use in automobile and furniture coatings.

Data were not collected in 1976 by the Bureau of Mines on specific end uses for iron oxide pigments, although a revised annual canvass will request this information in the future. Figures in table 2 do not necessarily reflect all sales of iron oxides used for pigments or other nonsmelting purposes. The largest percentage of iron oxide pigment consumption was in industrial coatings and trade sales (paints, stains, and varnishes). The construction industry also consumed iron oxide pigments in coloring cement, mortar, concrete blocks, and roofing granules. The pigments were also used to color plastics, rubber, and paper. A continually growing segment of the high-purity iron oxide market was in the manufacture of ferrites for magnetic and electronic applications. Some of the natural black magnetite was sold for use in heavy media in coal preparation plants.

The use of iron oxide pigments in cosmetics increased in 1976. A September ruling by FDA terminated the provisional approval of carbon black pigment for use in cosmetics;[6] therefore, producers of mascara and eyebrow pencils substituted iron oxide pigments in their products.[7]

PRICES

Prices of finished iron oxide pigments increased in 1976 in almost all categories. Synthetic pigment prices increased by 6.5 cents to nearly 10 cents per pound, while prices of some natural pigments rose even higher. Most price changes occurred in April and May, and the price of the two American siennas increased again in October. Prices in those categories increased more than 14 cents per pound by the last quarter.

[5] Indicated by quantity of finished iron oxide pigments sold plus imports of natural and synthetic iron oxide pigments minus exports of pigment-grade iron oxides and hydroxides.
[6] Federal Register. Termination of Provisional Listing of Carbon Black. V. 41, No. 186, Sept. 23, 1976, pp. 41857-41858.
[7] Chemical Week. Two Dyes Banned. V. 119, No. 13, Sept. 29, 1976, p. 19.

Table 5.—Prices quoted on finished iron oxide pigments, per pound, bulk shipments, December 31, 1976

Pigment	Low	High	Pigment	Low	High
Black:			Red:		
Synthetic	$0.3100	$0.3825	Domestic primers	$0.1725	$0.2300
Micaceous	.3800	.4000	Pure, synthetic	.3825	.4125
Brown:			Yellow:		
Ground iron ore	.0750	.0900	Synthetic	.3750	.4050
Metallic	.1175	.1275	Ocher, domestic	.0875	.0875
Pure, synthetic	.3650	.4500	Natural, French type	.1800	.2300
Sienna, American, burnt	.3075	.4000			
Sienna, American, raw	.2900	.3275			
Umber, Turkey, burnt	.2475	.2750			
Umber, Turkey, raw	.2200	.2475			

Source: American Paint Journal.

FOREIGN TRADE

The quantity of pigment-grade iron oxides and hydroxides exported from the United States in 1976 decreased 34% from that of 1975. Total value of exports, however, increased 33%, reflecting a twofold increase in average unit value. Exports to Canada, which comprise the largest percentage of total exports, fell 47% in 1976, while those to other countries either increased or remained close to 1975 levels.

The quantity of other grades of iron oxide exports increased 36% in 1976; values increased by 55%. Schedule B of the U.S. Department of Commerce Statistical Classification of Domestic and Foreign Commodities Exported from the United States defines other grade iron oxides and hydroxides as follows: Iron hydroxide, synthetic; iron oxide catalyst; iron oxide, synthetic (except pigment); and jeweler's rouge (synthetic ferric oxide).

Imports of iron oxide pigments for consumption increased 79% in 1976 compared with those of 1975, reflecting the strong upturn in demand. Value of imports increased 80%, which indicated only a small increase in average unit values.

Imports of synthetic iron oxides increased 85% over 1975 levels; 52% of synthetic imports came from West Germany and 29% came from Canada. Imports of synthetic pigments from Japan increased significantly in 1976. Imports of crude and refined natural pigments were 56% greater than 1975 imports; 71% of natural pigments were crude and refined siennas and umbers from Cyprus, while 12% were Spanish oxides.

Table 6.—U.S. exports of iron oxides and hydroxides, by country

Destination	1975				1976			
	Pigment grade		Other grade		Pigment grade		Other grade	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	130	$82	1	$3	158	$110	59	$141
Belgium-Luxembourg	20	17	14	12	1	1	261	262
Brazil	46	56	99	97	35	41	484	468
Canada	7,484	1,494	797	445	3,935	1,362	962	835
Colombia	15	10	5	2	15	13	41	34
Equador	3	4	2	1	9	12	1	1
Finland	7	5	--	--	28	22	--	--
France	103	106	179	171	158	196	149	157
Germany, West	143	81	241	480	125	89	307	640
Guatemala	12	6	4	6	2	2	71	85
India	--	--	32	8	(1)	1	8	17
Indonesia	--	--	59	26	3	4	--	--
Iran	--	--	159	269	2	2	--	--
Ireland	13	8	--	--	5	9	58	93
Italy	5	8	453	498	78	109	571	826
Japan	6	20	848	1,155	56	140	1,233	1,742
Korea, Republic of	24	11	4	6	151	153	254	399
Liberia	3	2	1	1	15	12	--	--
Mexico	96	50	139	148	78	70	178	200
Netherlands	49	32	525	708	96	75	411	717
Netherlands Antilles	(1)	1	--	--	--	--	45	59
New Zealand	2	1	--	--	14	9	--	--
Panama	3	3	36	5	--	--	--	--
Peru	30	10	7	10	2	2	4	3
Philippines	66	53	3	4	98	80	6	5
Portugal	--	--	23	25	--	--	64	91
Singapore	(1)	1	--	--	38	67	71	16
South Africa, Republic of	3	20	39	57	7	6	21	16
Spain	--	--	40	20	14	74	46	27
Taiwan	1	1	15	9	--	--	62	111
United Arab Emirates	--	--	27	44	--	--	50	135
United Kingdom	321	303	507	746	454	449	524	852
Venezuela	136	88	145	155	82	80	66	47
Other	59	50	47	76	146	163	55	56
Total	8,780	2,523	4,451	5,187	5,805	3,353	6,062	8,035

[1]Less than 1/2 unit.

Table 7.—U.S. imports for consumption of iron oxide pigments

Kind	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Natural:				
Crude:				
Ochers	--	--	--	--
Siennas	452	$91	466	$82
Umbers	3,894	282	6,223	421
Other	128	60	9	12
Total	4,474	433	6,698	515
Refined:				
Ochers	20	3	53	11
Siennas	69	16	158	40
Umbers	357	68	685	140
Vandyke brown	319	57	739	147
Other	873	163	1,222	178
Total	1,638	307	2,857	516
Synthetic	21,867	8,444	40,547	15,523
Grand total	27,979	9,184	50,102	16,554

Table 8.—U.S. imports for consumption of iron oxide and iron hydroxide pigments, by country

Country	Natural				Synthetic			
	1975		1976		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	40	r$20	39	$20	--	--	--	--
Belgium-Luxembourg	83	34	--	--	--	--	153	$69
Brazil	--	--	--	--	1	(1)	--	--
Canada	r10	4	29	5	7,625	$1,611	11,792	2,831
China, People's Republic of	11	1	11	2	4	3	5	12
Cyprus	4,134	309	6,761	492	--	--	--	--
France	3	2	(1)	1	--	--	16	6
Germany, West	260	r58	714	148	11,858	5,712	21,169	10,716
India	90	r11	--	--	--	--	--	--
Italy	398	94	386	90	--	--	--	--
Japan	r72	32	36	20	942	596	5,078	1,039
Korea, Republic of	55	24	--	--	--	--	--	--
Mexico	--	--	--	--	r607	210	845	299
Netherlands	--	--	--	--	--	--	69	36
Romania	--	--	20	7	--	--	1	(1)
South Africa, Republic of	20	3	40	7	--	--	--	--
Spain	684	r95	1,102	136	51	10	38	11
United Kingdom	r251	55	417	104	780	302	1,381	504
Total[2]	r6,111	740	9,555	1,032	21,867	8,444	40,547	15,523

rRevised.
[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

TECHNOLOGY

Waterborne coatings were being used increasingly in industrial finishes because of greater economy in energy and air pollution control costs. Market studies indicated that nearly half of total industrial coatings will be waterborne by 1977; therefore, pigment manufacturers were conducting research into the use of their products in aqueous systems. Pfizer Inc. tested iron oxide pigments in some waterborne coatings systems and concluded that many synthetic and natural oxides were suitable for use in most aqueous primers and top coats.[8]

In an effort to replace certain pigments containing lead, manufacturers tested combinations of organic and inorganic pigments. One auto maker reportedly formulated a combination of iron oxide with quinacridone magenta which closely matched the molybdate orange pigment that had been used.[9] Other manufacturers reportedly combined iron oxides with benzidine yellow to replace chrome yellow, and with pthalocyanine green to substitute for chrome green.[10]

The nontoxic nature of iron oxide pigments reportedly makes them suitable for use in the production of food and drug containers. Increased interest in the manufacture of plastic beverage containers led to research in the use of transparent iron oxides for pigmentation. The oxides were demonstrated to offer the transparency of a dye plus the optical property of screening out harmful ultraviolet rays. Transparent red oxide produced the amber shade required to prevent product deterioration in beer, medicine, and food oil bottles.[11]

In 1976, the University of Illinois at Urbana-Champaign, under a grant from Pfizer Inc., began research into possible uses for the waste from Pfizer's East St.

[8]American Paint & Coatings Journal. Iron Oxides and Extender Pigments for Aqueous Industrials Subject at Houston Meeting. V. 54, No. 17, Apr. 26, 1976. p. 52.
[9]———. The Markets. V. 60, No. 38, Mar. 1, 1976, p. 24.
[10]———. The Markets. V. 61, No. 4, Aug. 9, 1976, p. 24.
[11]Marvuglio, P. Ultraviolet Screening Properties of Transparent Pigments for Plastic Beverage and Packaging Applications. Presented at Soc. Plastic Engrs. Ann. Tech. Meeting, Atlantic City, N.J., Apr. 28, 1976, 23 pp.

Louis iron oxide pigment plant. Studies were made on the potential use of the waste material in ceramics, refractories, and soil conditioners for iron-deficient areas.[12]

Results of research on the sintering behavior of certain iron oxides were published in 1976. Specifically, oxides derived from the calcination of a variety of iron salts and their aqueous solutions were studied. It was concluded that oxides prepared from aqueous solutions absorbed more gases during sintering than those made from iron salt reagents. However, these oxides had the advantage of being more homogeneous within mixtures.[13]

A method was developed to produce an improved acicular iron oxide pigment for use in magnetic recording tape. The pigment optionally contained cobalt, nickel, and/or manganese. Improvement was reportedly due to the addition of zinc ion and phosphate ion, each in concentrations of about 0.1% to 2% by weight, during precipitation; this produced acicular iron hydroxide crystals, free from dendritic growths. Reduction and reoxidation of the dendrite-free particles produced a magnetic pigment with improved orientability.[14]

A Japanese producer of titanium dioxide developed a process for recovering sulfuric acid from plant wastes. The process features solvent extraction instead of conventional ammonia or calcium neutralizing treatments and generates a byproduct high-purity iron oxide suitable for use in pigments and ferrites.[15]

A paper, presented at the 1976 annual meeting of the American Ceramic Society, reviewed the history and development of the ferrite industry. Recent research and a bibliography were included.[16]

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[12]Chemical Engineering News. Concentrates. V. 54, No. 6, Feb. 9, 1976, p. 16.

[13]Gallagher, P. K., D. W. Johnson, Jr., and F. Schrey. Some Effects of the Source and Calcination of Iron Oxide on Its Sintering Behavior. Ceramic Bulletin, v. 55, No. 6, June 1976, pp. 589-593.

[14]Woditsch, P., G. Buxbaum, F. Hund, and V. Hahnkamm (assigned to Bayer Aktiengesellschaft, Leverkusen, Germany). Magnetic Iron Oxides with Improved Orientability and a Process for Their Production. U.S. Patent 3,931,025, Jan. 6, 1976.

[15]American Metal Market. Japanese Titanium Dioxide Producers Consider New Acid Recovery Method. V. 83, No. 76, Apr. 19, 1976, p. 27.

[16]Brockman, F. G. Development of Ferrites and Other Ferromagnetic Oxide Ceramics. Pres. at American Ceramic Society Ann. Meeting, Cincinnati, Ohio, May 3, 1976, 3 pp; Ceramic Bull., v. 56, No. 2, February 1977, pp. 216-218.

Iron and Steel

By H. T. Reno[1] and D. H. Desy[2]

In 1976, the world iron and steel industry had not completely recovered from the recession of 1975, although most countries produced as much or more steel than in 1975. The European Communities (EC) and Japan showed increases of 6% and 5%, respectively, while the Eastern European countries registered an increase of 3%, and the People's Republic of China showed a 6% decrease.

The United States produced 128 million tons[3] of raw steel,[4] 10% more than in 1975, but 12% less than in 1974. Weekly steel production rose from 2,005,000 tons at the beginning of the year to a high of 2,759,000 tons at the end of May before declining to 2,000,000 tons by yearend.

According to the American Iron and Steel Institute (AISI), the steel industry shipped 89.4 million tons of steel products, 12% more than in 1975. Industry sectors receiving the largest quantities of steel shipments were the automotive industry with 24% and steel service centers and distributors with 16%. Steel prices rose by an average of approximately 8.5% during the year. The United States imported 13.1 million tons and exported 3.7 million tons of steel in 1976.

Legislation and Government Programs.— Under the terms of the Trade Act of 1974, the U.S. International Trade Commission on January 16, 1976, reported to the President the results of an investigation of imports of stainless and alloy tool steel (specialty steel). The Commission determined that bars, wire rods, plates, sheets, and strip of specialty steel were being imported into the United States in such increased quantities as to cause serious injury or a threat thereof to the domestic specialty steel industry. The Commission recommended that quotas be established for these products for a period of 5 years beginning in 1976. The President first sought orderly marketing agreements with the principal countries involved and concluded an agreement with the Government of Japan. Since agreements were not reached with other countries, import quotas were established effective June 14, 1976, for a period of 3 years. Quotas were based on the annual average quantity or value of specialty steel imported during the period 1971-75.[5]

On March 29, 1976, the Environmental Protection Agency (EPA) promulgated interim final effluent (water) limitations for forming, finishing, and specialty steel operations in the iron and steel industry. These standards were developed on the average of the best performance of existing plants in the industry. Regulations for best available technology economically achievable and new source performance standards were proposed on the same date.[6]

On October 6, 1976, the Office of the Special Representative for Trade Negotiations received a petition from the AISI alleging unfair trade practices by the European Coal and Steel Community (ECSC) and the Ministry of International Trade and Industry (MITI) of Japan resulting from a bilateral agreement between ECSC and MITI, which allegedly diverted significant quantities of Japanese steel exports to the United States. The complaint was filed pursuant to Section 301 of the Trade Act of

[1]Supervisory physical scientist (now retired), Division of Ferrous Metals.
[2]Physical scientist, Division of Ferrous Metals.
[3]Tons in this chapter refer to short tons of 2,000 pounds.
[4]The term raw steel, as used by American Iron and Steel Institute, includes ingots, steel castings, and continuously cast steel. It corresponds to the term crude steel as used by the United Nations.
[5]Federal Register. Title 3—The President; Proclamation 4445—Temporary Quantitative Limitation on the Importation Into the United States of Certain Articles of Stainless Steel or Alloy Tool Steel. V. 41, No. 116, June 15, 1976, pp. 24101-24105.
[6]Federal Register. Title 40—Protection of the Environment; Chapter I—Environmental Protection Agency; Part 420—Iron and Steel Manufacturing Point Source Category. Effluent Guidelines and Standards. V. 41, No. 61, Mar. 29, 1976, pp.12990-13030.

1974. The Committee was considering the petition at yearend.

The Occupational Safety and Health Administration (OSHA) of the Department of Labor issued standards for controlling exposure of steelworkers to cancer-causing emissions from coke ovens, effective January 20, 1977. The new rules call for limiting worker exposure around the ovens to 0.15 milligram of the benzene-soluble fraction of total particulate matter per cubic meter of air as determined for an 8-hour period. Engineering controls for emissions must be instituted by January 20, 1980.[7]

Table 1.—Salient iron and steel statistics

(Thousand short tons)

	1972	1973	1974	1975	1976
United States:					
Pig iron:					
Production	88,876	r101,318	95,477	79,721	86,848
Shipments	89,053	101,628	95,941	79,240	86,693
Exports	15	15	101	60	58
Imports for consumption	637	446	342	478	444
Steel:[1]					
Production of raw steel:					
Carbon	117,698	132,747	126,608	100,360	112,008
Stainless	1,564	1,889	2,150	1,111	1,684
All other alloy	13,979	16,163	16,962	15,171	14,308
Total	133,241	150,799	145,720	116,642	128,000
Index[2]	104.5	118.5	114.5	NA	NA
Capability utilization[3]	NA	NA	NA	76.2	80.9
Total shipments of steel mill products	91,805	111,430	109,472	79,957	89,447
Exports of major iron and steel products	3,546	4,962	6,992	3,975	3,671
Imports of major iron and steel products	18,158	15,608	16,746	12,488	13,096
World production:					
Pig iron	500,000	552,000	r564,000	r529,000	549,000
Raw steel (ingots and castings)	693,000	769,000	780,000	713,000	748,000

rRevised. NA Not available.

[1]American Iron and Steel Institute (AISI).

[2]Based on average production in 1967 as 100. Not computed after 1974.

[3]Defined by AISI as the capability to produce raw steel for a full order book based on the current availability of raw materials, fuels, and supplies; and of the industry's coke, iron, steelmaking, rolling and finishing facilities, recognizing current environmental and safety requirements. Not computed before 1975.

PRODUCTION AND SHIPMENTS OF PIG IRON

Domestic production of pig iron totaled 86.8 million tons in 1976, an increase of 7.1 million tons or 9% more than that produced in 1975. Average production of pig iron per blast furnace day increased to 1,930.1 tons compared with 1,837.4 tons in 1975 and 1,728.0 (revised) tons in 1974, according to AISI. A total of 119 furnaces were in blast at the beginning of the year. At yearend the total number in blast had decreased to 107, including 1 that produced ferroalloys which was relit during the year. There was a total of 196 blast furnaces at the beginning of the year and 193 at yearend, of which 7 were being relined and 1 rebuilt.

Metalliferous Materials Consumed in Blast Furnaces.—For each ton of pig iron produced in 1976, an average of 1.660 tons of metalliferous materials was consumed in blast furnaces. Total net iron ore and agglomerates consumed in blast furnaces was 136.8 million tons. The total tonnage of iron ore, including manganiferous ore, consumed by agglomerating plants at or near the blast furnaces in producing 36.7 million tons of agglomerates was 25.8 million tons. The remainder consisted of mill scale, flue dust, slag, coke breeze, limestone, dolomite, and small quantities of other materials. Domestic pellets charged to the blast furnaces totaled 69.5 million tons, and sinter charged was 36.5 million tons. Pellets and

[7]Federal Register. Title 29—Labor; Chapter XVII—Occupational Health and Safety Administraion, Department of Labor; Part 1910—Occupational Health and Safety Standards. Exposure to Coke Oven Emissions. V. 41, No. 206, Oct. 22, 1976, pp.46742-46790.

other agglomerates from foreign sources amounted to 15.2 million tons.

Blast furnace oxygen consumption totaled 26.9 billion cubic feet according to AISI, compared with 25.9 billion cubic feet in 1975 and 25.8 billion cubic feet in 1974.

Data reported to the Bureau of Mines by the iron and steel industry showed that blast furnaces, through tuyere injection, consumed 9.7 billion cubic feet of natural gas, 8.1 billion cubic feet of coke oven gas, 479 million gallons of oil, 152 million gallons of tar, pitch, and miscellaneous fuels, and 157,671 tons of bituminous coal in 1976.

PRODUCTION AND SHIPMENTS OF STEEL

The domestic steel industry produced 128.0 million tons of raw steel in 1976, 10% more than the 116.6 million tons produced in 1975. Production in 1976 equaled 80.9% of industry raw steel production capability compared with 76.2% in 1975. Of the total, 62.5% was produced by the basic oxygen process; 18.3%, by open-hearth furnaces; and 19.2%, by electric furnaces. Shipments of steel products for the year totaled 89.4 million tons, 12% more than the 80 million tons shipped in 1975.

Shipments to the automotive industry totaled 21.4 million tons, 40% higher than in 1975, and shipments to service centers were up 15%, to 14.6 million tons. Shipments to the oil and gas industries and to the construction market were down 15% and 8%, respectively.

Materials Used in Steelmaking.—Metallic materials charged to domestic steel furnaces in 1976, per ton of steel produced, averaged 1,280 pounds of pig iron, 993 pounds of scrap, and 22 pounds of iron ore, including agglomerates. Revised figures for 1975 were 1,278 pounds of pig iron, 996 pounds of scrap, and 23 pounds of ore and agglomerates.

According to AISI, steelmaking furnaces consumed 586,486 tons of fluorspar, 1.5 million tons of limestone, 7.6 million tons of lime, and 1.3 million tons of other fluxes. Oxygen consumption in steelmaking totaled the equivalent of 196.3 billion cubic feet compared with 178.4 billion cubic feet in 1975.

CONSUMPTION OF PIG IRON

Total pig iron consumed in 1976 was 87.0 million tons. In steelmaking, basic oxygen converters consumed 66.1 million tons; open hearths, 15.4 million tons; and electric furnaces, 0.4 million tons. In addition, 1.3 million tons were used by iron foundries and miscellaneous users, principally for charging cupola furnaces. Also, 3.3 million tons was used in making ingot molds and other direct castings.

PRICES

Price increases totaling 12% on sheet and strip and 6% to 8% on other steel mill products went into effect during the year. Prices of tubular products and rails were raised 6% and 7%, respectively, effective May 1, followed by a 6% rise on sheet and strip, effective June 14. Structural steel shapes and plate prices were raised 6% to 8%, effective July 16. A proposed rise in price of 4.5% on sheet and strip, announced in August, to be effective October 1, was later canceled. The final price increase of the year was an additional 6% on sheet and strip, effective December 1.

The composite price for pig iron, according to Iron Age magazine, remained throughout 1976 at $187.67 per ton where it had been since February 1975. The Iron Age finished steel composite price rose from 13.693 cents per pound at the beginning of the year to 14.880 cents at yearend, for a yearly average price of 14.213 cents per pound. This was an 8.5% increase over average 1975 prices.

FOREIGN TRADE

Exports amounted to 3.7 million tons in 1976, 8% less than in 1975. The value of steel exported totaled $2.46 billion resulting in an unfavorable balance of trade of $1.67 billion.

In 1976, the United States imported 13.1 million tons of iron and steel products valued at $4.13 billion, up 5% in tonnage but down 8% in value compared with 1975 figures.

Japan supplied 56% of the total steel mill products imported; the EC supplied 22%; and Canada, 9%. Imports were up 37% from Japan, down 23% from the EC, and up 29% from Canada compared with 1975 imports.

Japan supplied 57% of the carbon steel, 41% of the alloy steel, and 53% of the stainless steel imported, and the EC supplied 22% of the carbon steel, 24% of the alloy steel, and 23% of the stainless steel. Canada supplied 25% of the alloy steel, and Sweden, 10% of the stainless steel imports.

WORLD REVIEW

NORTH AMERICA

Canada.—Canadian industry was slightly more active in 1976 than in 1975, but Canada's steel industry lagged behind the overall economy. Compared with 1975, raw steel production increased 1% to 14.5 million tons.

In December, Sidbec-Dosco Ltd. filed a formal complaint with the Canadian Government, alleging dumping of Japanese hot-rolled angle bars. Other Canadian steel companies were expected to follow suit.

In view of the depressed market, the Steel Co. of Canada delayed until 1980 the expected completion of the first phase of its new steelmaking plant at Nanticoke, Ontario. Sidbec-Dosco Ltd. requested financial assistance from the Provincial Government.

Mexico.—The Mexican steel industry continued an expansion program with the expectation of raising annual capacity to 13.5 million tons by 1980, although some of the expansion projects fell slightly behind schedule. The newly built No. 2 steelworks of Altos Hornos de México S.A. (AHMSA) at Monclova in Coahuila was inaugurated by President Luis Echeverria on September 18, 1976. This plant will increase the raw steel production capacity of AHMSA from 2.2 to 4.1 million tons per year. The first stage of the $900 million steel plant Siderúrgica Lázaro Cárdenas-Las Truchas (SICARTSA) was essentially completed by yearend.

The Mexican steel industry experienced environmental problems similar to those of steel industries in the United States and Japan. The Fundidora steel mill at Monterrey, Nuevo Leon, reported that it had spent an estimated 400 million pesos to decrease emission of air pollutants from 4 tons to about 4 pounds per day.[8]

The Government steel research institute, Instituto Mexicano de Investigaciones Siderurgicas (IMIS), established by official decree May 13, 1975, was organized during the year. A board of directors and a Director General were appointed.[9]

SOUTH AMERICA

The annual meeting of the Latin American Iron and Steel Institute (ILAFA) was held in Caracas, Venezuela, in October 1976. Discussion of the future of the steel industry in South America was optimistic, but at the same time it was pointed out that there were still serious obstacles to growth. The most significant obstacle, according to several observers, was the lack of trained manpower, which overshadowed the limited supply of coal that was of concern in 1975. The Latin American iron and steel industry had a capital availability problem similar to that of the industries of the United States and European countries. Capital costs for new plant construction were reported to be similar to those in the United States, at approximately $1,000 per ton of raw steel capacity. There was general agreement, however, that there is no real reason why the Latin American iron and steel industry could not become a power in world steel trade. The ILAFA annual meeting was followed by a congress on basic oxygen steelmaking, part of ILAFA's long-term program to promote the industry in South America.

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[8]U.S. Consulate, Monterrey, Mexico. State Department Airgram A-23, Aug. 23, 1976, 7 pp.; and U.S. Embassy, Mexico City, Mexico. State Department Airgram A-246, Aug. 19, 1976, 3 pp.

[9]U.S. Embassy, Mexico City, Mexico. State Department Airgram A-78, Mar. 17, 1976, 2 pp.

Argentina.—The Argentine steel industry produced 2.65 million tons of raw steel in 1976 compared with 2.50 million tons produced in 1975. Acindar, Industria Argentina de Aceros S.A., the private Argentine steel company that was authorized in January 1975 to build a new steelworks at Villa Constitucion in the Province of Santa Fe, received a $70 million loan from the Inter-American Development Bank to help finance its expansion program. The plant will include a Midrex direct-reduction plant, electric furnaces, and continuous casting equipment. An additional $20 million loan was obtained from the U.S. Export-Import Bank, mainly for the Midrex plant. The projected capacity of the plant will be 660,000 tons per year.[10]

La Cantábrica Sami y C, manufacturer of rolled steel products, contracted with a major Argentine engineering firm for a feasibility study to evaluate alternatives for improving its steel forming facilities.[11]

Bolivia.—The Government of Bolivia decided to install a $500 million iron and steel complex based on the Mutún iron ore deposit. The Mutún complex will produce 220,000 tons per year of low-carbon steel, using charcoal blast furnaces. Future plans call for an additional 660,000 tons per year of direct-reduced iron, using a natural gas process.[12] In a related operation the Bolivian Government hydrocarbons company signed an agreement with the Government of Argentina to provide an additional 2 million cubic meters (71 million cubic feet) of natural gas per year beginning in 1979. This brings the total contracted quantity to 6.5 million cubic meters (230 million cubic feet) in 1979.[13]

Brazil.—The Brazilian steel industry operated at a relatively high level of activity, producing 11% more raw steel and 24% more direct-reduced iron than in 1975. However, expansion plans under the stage 2 program were running about a year behind schedule at the Volta Redonda plant of Cia. Siderúrgica Nacional (CSN), and costs were substantially higher than previous estimates. Nevertheless, Brazilian officials affirmed that stage 3 expansion would not be significantly affected and that construction would proceed about on schedule. The expansion program apparently was being slowed by a shortage of skilled labor and late delivery of domestically produced equipment.

The Brazilian company, Siderúrgica Brasileira S.A. (SIDERBRAS), Kawasaki Steel Corp. of Japan, and Finanziaria Siderúrgica S.p.A. (FINSIDER) of Italy agreed to form a cooperative enterprise for construction of an integrated steelworks for the manufacture of semifinished steel. Initial annual slab capacity will be 3.3 million tons. First phase equipment will include a blast furnace, basic oxygen furnaces, and a slabbing mill.[14]

Chile.—Expansion plans of Compañía de Acero del Pacífico, S.A. (CAP), the State-owned vertically integrated company that produces more than 90% of Chile's iron and steel, were delayed because of the shortage of capital and losses in steelmaking operations.

Venezuela.—The Venezuelan iron and steel industry apparently was less affected by the worldwide economic stagnation than that of any other South American country. Profits from the Venezuelan petroleum industry permitted expansion of the nationalized steel industry about as planned, and the high level of economic activity enabled secondary industries in the private sector to expand operations. The only serious obstacle to steel industry growth was lack of trained manpower and the normal difficulties encountered in starting up new operations.

The Government was moving ahead rapidly with its plan to install 16.5 million tons per year of steelmaking capacity by 1990 or soon thereafter. All of the integrated steelmaking operations in 1976 were at the Government-owned plant of Corporacion Venezolana de Guayana-Siderurgica del Orinoco (CVG-SIDOR). To utilize the iron ore and natural gas resources of the Guayana region, Sidor chose the direct reduction-electric furnace route for its expansion program. Initially two plants, one using the Midrex process with a capacity of 390,500 tons and the other using the Hojalata y Lámina (HyL) process with a capacity of 396,000 tons, had been constructed. Before operation of the two systems could be compared, pressure to complete the expansion plan caused Sidor to contract for plants from both firms. The HyL plant, to be built by Pullman-Swindell, will have three mod-

[10]Engineering and Mining Journal. News Briefs. Argentina. V. 177, No. 6, June 1976, pp. 320, 322.
[11]U.S. Embassy, Buenos Aires, Argentina. State Department Airgram A-119, Aug. 3, 1976, 2 pp.
[12]U.S. Embassy, La Paz, Bolivia. State Department Telegram 8465, Oct. 21, 1976, 3 pp.
[13]U.S. Embassy, La Paz, Bolivia. State Department Telegram 8278, Oct. 15, 1976, 2 pp.
[14]Griffin, S. Joint Steel Venture in Brazil Starts Building Next Spring. Steel Times, v. 204, No. 9, September 1976, p. 820.

ules with a total production capacity of over 2.2 million tons, and the Midrex plant, also with three modules, will have a capacity of 1.4 million tons of sponge iron per year.[15] Continuing its expansion plans, the Government approved construction of an iron and steel plant in western Venezuela in the State of Zulia having a capacity of 5.5 million tons of raw steel. The plant will be based on blast furnace-basic oxygen technology.

In the private sector, the National Steel Council approved eight new steel projects and recommended that four others be approved without State-supported financing. One of the largest projects was the second and third stage expansion program of Siderúrgica Venezolana S.A. (SIVENSA) to raise steelmaking capacity to 440,000 tons per year. However, SIVENSA's expansion will probably depend on operation of the Fior de Venezuela direct reduction plant which began operating toward the end of the year. When a steady supply of briquets from the Fior plant is available, SIVENSA is to add a second electric arc furnace, doubling its Guayana plant capacity to 220,000 tons per year. The most significant development in the private sector was the start of operations at the Fior de Venezuela fluidized-bed direct reduction process plant. CVG owns one-third of Fior de Venezuela; SIVENSA and Lukens Steel Co. of the United States are minority stockholders.

EUROPE

The steel industries of the Western European countries, whose business had been seriously damaged by the worldwide economic recession in 1975, recovered slightly in the first part of 1976, but the recovery was short-lived. Increasing costs and deteriorating domestic markets resulted in a depressed situation through most of the year.

Members of the EC were most concerned with the economic condition of their steel industries. The EC Commission studied the steel industry problems throughout the year and late in November approved a program that contained provisions for improved analysis and monitoring of steel markets, improved information exchange between nations, voluntary production targets, and minimum prices. It was determined that it would be necessary to attempt to predict fluctuations in the steel market, and in order to do so, statistical data on production, consumption, stock levels, employment, external trade, and utilization of capacity should be monitored more closely. Setting of minimum reference prices was included as a secondary measure if voluntary quotas proved inadequate as price supports. Toward the end of the year it was determined that a crisis situation existed, and the program, including voluntary quotas, was put into effect for a period of 4 months, beginning January 1, 1977.[16]

Early in the year, the national steel associations of Belgium-Luxembourg, the Netherlands, and the Federal Republic of Germany announced the formation of an international steel federation, to represent their interests before the EC. Later, an organization representing the steel producers of the entire EC was founded, known as the European Confederation of Iron and Steel Industries (EUROFER).

The Standing Commission on the Iron and Steel Industry of the Council for Mutual Economic Assistance (CMEA) of Eastern Europe reported that the CMEA countries had agreed on technical and scientific cooperation on direct reduction of iron ores and agreed to set up a coordination center in Romania. The Council approved a long-term plan for operation of the international system of scientific and technical information on ferrous metallurgy.[17]

Belgium.—Belgium's steel industry recovered slightly from the low of 1975 and it operated at 70% to 75% of capacity. Belgium's international trade in steel declined. Officials of Belgium's steel industry participated in discussions of the EC program and sought assistance in the Community. In addition, the industry was gradually instituting rationalization of operations and product specialization.

France.—The French steel industry recovered slowly from the depressed state of 1975. Operations returned to normal by April, with the resumption of full-time work schedules. However, normal operations did not continue, and in the last 2 months of the year the industry was forced to shorten the working time of approximately 50,000 steel workers. The industry experienced low worker productivity throughout the year, especially during the periods of shortened working time. Despite this depressed condition, the ECSC loaned France another

[15]U.S. Embassy, Caracas, Venezuela. State Department Airgram A-149, Nov. 4, 1976, 36 pp.

[16]U.S. Mission EC, Brussels, Belgium. State Department Airgram A-530, Dec. 7, 1976, 1 p.; and Telegram 12551, Dec. 20, 1976, 2 pp.

[17]CMEA Secretariat Report for the 44th Session of the United Nations Economic Commission for Europe. Steel Committee meeting at Geneva, Switzerland, October 1976. Prepared in Moscow, July 1976, 12 pp.

$11.5 million for the Solmer steelworks at Fos-sur-mer west of Marseilles.[18]

A new steel mill with an annual capacity of 3.5 million tons will be built by Société des Aciéries et Laminoirs de Lorraine (SACILOR) to replace an older mill at Sérémange in the Lorraine area. The mill is to have two 240-ton basic oxygen furnaces, with continuous slab casting. New coke ovens will be installed, and the blast furnaces and hot rolling mills modernized.[19]

Germany, West.—The steel industry of West Germany fared slightly better than its European Community partners because of a lower inflation rate and improved industrial economy. However, its foreign trade in steel mill products showed the effect of keen competition. Imports of steel mill products were up slightly while exports of these products were down about 10% compared with exports in 1975.

The EC Commission approved the acquisition by Klöckner-Werke AG of the majority share of Eisenwerke-Gesellschaft Maximilianshütte m.b.H. of Sulzbach-Rosenberg. The combined steel group will be the fourth largest raw steel producer in West Germany after August Thyssen-Hütte AG, Estel NV, and Fried. Krupp Hüttenwerke AG.

Italy.—Italy experienced a monetary inflation rate of about 16% during the year, and the lira continued to weaken in relation to the currency of Italy's trading partners. Among the difficulties faced by the steel industry were substantial increases in labor costs resulting from renegotiated labor contracts, and in raw material costs, partly as a result of devaluation of the lira. However, the industry was helped somewhat by heavy industrial buying of steel as a hedge against further inflation. The industry operated at less than 70% of capacity during the year.

Luxembourg.—The Luxembourg steel industry, one of the most severely affected by the recession of 1975, showed no recovery in 1976. Steel plants operated at 50% to 60% of capacity. Since steel represents 30% of gross national product and 95% of production is exported, the effect on the country's economy and trade was severe. The two largest steelworks announced a reduction from three to two shifts, affecting a total of 1,100 steelworkers. As a result, the usually harmonious relationship between the industry and labor was threatened.[20]

Spain.—Stocks of steel in Spain increased by more than 1 million tons, and raw steel production was slightly below that of 1975. As a prerequisite for funding, the Spanish Government apparently required that electric furnace steelmaking expansion include provisions for a direct reduction operation to lessen reliance on imported scrap.[21] There were two projects for direct reduction of iron ore: One was to be located in northern Spain near the port of Bilbao with two modules having a total capacity estimated at between 1 and 1.2 million tons annually; and the other was to be located on the Bay of Algeciras in southern Spain with one module and production capacity of approximately 500,000 tons per year. Both projects will use gaseous reduction and were included in Spain's new concerted action program for the iron and steel industry. They were planned for completion by December 31, 1980.[22]

Sweden.—A Government-sponsored fund for countercyclical stockpiling of steel was extended to the end of the year. Part of the increase in steelmakers' stocks was attributed to this incentive program. The purpose of the plan was to maintain employment levels and to stockpile steel in anticipation of the next economic upturn.

In the first of many reorganization moves that were being negotiated during the year among the country's specialty steel producers, Uddeholms AB agreed to purchase the specialty steel operations of Stora Kopparbergs Bergslags AB effective January 1, 1977. Uddeholms will take over Stora's main specialty mill at Söderfors, while its rolling mill at Vikmanshytten is being negotiated for by Fagersta Bruks AB. Stora agreed with Gränges AB to cease heavy plate production at Domnarvet and transfer it to Gränges' Oxelösund works.

The planned construction of a new steelworks at Lulea in northern Sweden (Steelworks 80) by the State-owned company Norbottens Järnwerk AB (NJA) was set back during the year. The Government first revised the planned capacity from 4.4 million to 2.75 million tons per year in March, and after the electoral defeat of the Socialist Government, which had sponsored the plan,

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[18] American Metal Market. French Steel Project Receives Added Aid. V. 83, No. 179, Sept. 13, 1976, p. 36.

[19] U.S. Consulate, Strasbourg, France. State Department Airgram A-23, Mar. 10, 1976, 1 p.

[20] U.S. Embassy, Luxembourg. State Department Telegram 1131, Dec. 9, 1976, 3 pp.

[21] American Metal Market. Spain Ties Direct Reduction to Electric Furnace Funding. V. 83, No. 100, May 21, 1976, p. 5.

[22] U.S. Embassy, Madrid, Spain. State Department Airgram A-88, May 11, 1976, 1 p.

the future of the entire project was in doubt.

United Kingdom.—The British Steel Corp. (BSC) reported a loss of $459 million for fiscal 1975-76, compared with a profit of $131 million attained in 1974-75. It produced 18.9 million tons of raw steel, 17% less than in 1975. Finished steel deliveries were 13.4 million tons, 16% less than in 1975. Employment was reduced by 8% to 210,200 in the United Kingdom, and capital expenditures amounted to $954 million, 41% higher than those of 1974-75. Under the modernization plan, new equipment and construction valued at over $360 million was commissioned during the year. The corporation lost a portion of its home market to foreign competition, although its prices for most products were comparable to those prevailing in Europe. The ECSC loaned $300 million to BSC to finance modernization and expansion projects in the coal and steel sector. These funds were used to finance a major improvement program at BSC's Redcar-South Teeside complex. The planned expansion will make this complex one of the largest in the EC with a projected capacity of 5.5 million tons of raw steel per year.

After more than 9 months of delay because of a labor dispute with the National Union of Blastfurnacemen, the United Kingdom's largest blast furnace was lit on February 16, 1976, at the Llanwern works at Newport, Monmouthshire, Wales. The new furnace has a hearth diameter of 11.2 meters (36.7 feet) an inner volume of 2,652 cubic meters (93,620 cubic feet), and design production capacity of 5,500 tons per day. It is the first of the new generation of large blast furnaces being constructed under BSC's expansion plan.

The fourth mini-steelworks in the United Kingdom was commissioned by Manchester Steel Co. (part of the Norwegian group, Elkem-Spigerverket A/S of Oslo), located 3 miles from Manchester. The plant is equipped with a 50-ton electric arc furnace and a four-strand continuous casting machine to produce 90- to 115-millimeter (3.5- to 4.5-inch) square billets. Production capacity is 132,000 tons per year. A gas-fired scrap preheater is expected to increase production by about 10%.[23]

U.S.S.R.—One of the world's largest blast furnaces at Krivoy Rog in the Ukraine was reported to be operating at half of its ultimate capacity of 4.4 million tons per year. Plans were proceeding for a second unit at the same site. A new medium-size section rolling mill was installed at the Western Siberian Steel Plant, and a light section mill was added at the Nigne-Serginsky plant.

AFRICA

South Africa, Republic of.—The first stage of the Newcastle works of the Government-owned South African Iron and Steel Industrial Corp. Ltd. (ISCOR) was virtually completed during the year. Present annual production at this plant is 825,000 tons of raw steel. This is expected to increase to 2 million tons when the new No. 5 blast furnace is in production. Pig iron produced at the plant is transported by ladle car several miles to the basic oxygen shop, which consists of three 165-ton converters. The steel is continuously cast in three machines producing blooms of 315 by 205 millimeters (12.4 by 8.1 inches). The blooms are rolled to billets and to bars, sections, and wire rod. The planned capacity of the plant is 9 to 10 million tons per year.

Expansion of the Newcastle plant was deferred in favor of expanding the capacity of the Vanderbijlpark plant. This plant now has a capacity of 3.6 million tons of raw steel and is scheduled to reach 4.4 million tons soon. Reportedly, the ISCOR minimum steelmaking capacity by 1980-83 will be 7.7 million tons, as follows: Vanderbijlpark works, 4.4 million tons; Newcastle works, 2.0 million tons; and Pretoria works, 1.3 million tons.[24] Plans for the construction of a plant for production of semifinished steel products at Saldanha Bay, near the iron ore terminal, have been deferred.

ASIA

China, People's Republic of.—Information on the Chinese iron and steel industry continued to be scarce through 1976. However, the industry appears to have suffered a temporary setback probably mainly resulting from the recent severe earthquakes that affected coal and steel producing regions. China continued to import a considerable portion of its steel needs from Japan; however, the total for 1976 fell below the total of 4.4 million tons imported

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[23]Hallatt, E. S. Manchester Steel: Britain's Latest Mini-mill. Iron and Steel Internat., v. 49, No. 1, 1976, pp. 19-23.

[24]U.S.Consulate, Durban, South Africa. State Department Airgram A-64, Oct. 7, 1976, 4 pp.

in 1975. Purchases of special steels were to be negotiated separately.[25]

India.—In Indian fiscal year 1975-76 (April 1-March 31), the average rate of capacity utilization was 84% compared with 74% in 1974-75. However, the steady uptrend in production and increasing rate of utilization of capacity was not accompanied by the expected growth in demand.[26] The high rate of production resulted in further accumulation of unsold stocks of both steel and pig iron to record amounts. Inability to sell in the domestic markets spurred a sharp rise in iron and steel exports, although India continued to have a trade deficit in steel.

Japan.—Japan's steel industry recovered slowly during 1976 from the recession of 1975. Domestic sales and exports improved through the end of the summer but slumped toward the end of the year owing to adverse economic conditions at home and abroad. Pig iron production was about the same as that in 1975, but raw steel production rose about 5% to 118 million tons in 1976. Steel exports amounted to 41 million tons, a 24% increase over those of 1975.

The first phase of operation of Nippon Kokan's Ogishima Works was initiated with the blowing in on November 12, 1976, of No. 1 blast furnace. This furnace has an inner volume of 4,052 cubic meters (143,092 cubic feet). The Ogishima project, which was begun in 1969 as a replacement for the Keihin works, is located on a manmade island in Tokyo Bay, 1 3/4 miles from the mainland. The first stage will include coke ovens with dry quenching facilities, two 275-ton basic oxygen furnaces, continuous slab casting, and slabbing, billet, and plate mills.

The No. 2 blast furnace at Nippon Steel's Oita Works, which started operating on October 5, 1976, was reported to be the world's largest blast furnace, with an inner volume of 5,070 cubic meters (179,042 cubic feet), a hearth diameter of 14.8 meters (48.6 feet), and an output of 13,200 tons per day.

With the lighting of No. 3 blast furnace, having an internal volume of 5,050 cubic meters (178,336 cubic feet), the Kashima Works of Sumitomo Metal Industries Ltd. became Japan's fifth largest steelworks.

Philippines.—Philippine officials considered establishment of an integrated iron and steel industry to be completed in 1981 at an estimated cost of $1.2 billion.

OCEANIA

Australia.—The possibility of constructing a large steel complex in Western Australia was still being considered. A group of Australian, American, Japanese, and European firms continued the feasibility study which began in 1974, but inflation and high construction costs delayed the project.[27] The proposed plant would use Australian iron ore and coal and produce semifinished steel for final processing by individual participants. Three major sites in Western Australia were being considered: Moore River, Kwinana, and Port Hedland. As an alternative to a conventional steel plant, direct reduction of iron ore by natural gas from the North West Shelf area was being considered.

New Zealand.—New Zealand Steel Ltd. continued planning a large expansion project including establishment of hot and cold rolling facilities and a substantial increase in capacity, to raise production capacity to a minimum of 495,000 tons per year.[28]

TECHNOLOGY

Studies on the application of nuclear energy to steelmaking were conducted in the principal steelmaking areas of the world: The United States, Japan, and Western Europe. No information was available on nuclear research in the centrally planned economy countries. These studies were justified on the basis of conservation of natural resources such as metallurgical coal and other fossil fuels, as well as possible economic advantages.

The first report of an AISI task force set up to make a technical and economic study of various nuclear steelmaking concepts was published.[29] All the concepts studied were based on direct reduction and electric arc-furnace steelmaking, in which iron ore is first reduced in the solid state to the metal with a hot reducing gas, and the metal then melted and refined in the electric arc furnace. The studies indicated that a steelmaking system using a nuclear-heated coal-gasification process to produce gas for direct reduction of iron ore could be competitive or even provide a slight eco-

[25]U.S. Embassy, Tokyo, Japan. State Department Telegram 486, Oct. 21, 1976, 2 pp.

[26]U.S. Consulate, Calcutta, India. State Department Airgram A-23, Aug. 16, 1976, 31 pp.

[27]U.S. Embassy, Canberra, Australia. State Department Airgram A-125, Nov. 12, 1976, 15 pp.

[28]U.S. Embassy, Wellington, New Zealand. State Department Airgram A-137, Dec. 14, 1976, 9 pp.

[29]Blickwede, D. J. Nuclear Steelmaking in the U.S.—Prospects and Plans. Iron and Steel Eng., v. 53, No. 4, April 1976, pp. 38-44.

nomic advantage over the present coke-oven, blast-furnace, basic oxygen furnace operation. The system studied in detail by the task force visualized a very high temperature reactor (VHTR), which would offer economic advantages over conventional methods of coal gasification only when built to a much larger scale than a conventional plant. Sharing of the gas output of a large VHTR between several steel or chemical plants would probably be necessary. It was concluded that in view of the uncertainty in the technology of the reactor, in cost estimates, and in the future availability and cost of various forms of energy, it would be desirable to conduct a research program on the VHTR. The task force recommended that the Energy Research and Development Administration (ERDA) finance such a program at the level of $3 to $5 million per year.

In Japan, studies on nuclear steelmaking have been conducted since 1968, and in 1973, a Government-supported consortium, Engineering Research Association of Nuclear Steelmaking (ERANS), was formed to conduct a 6-year research and development project. This project was directed toward construction of an integrated nuclear steelmaking plant utilizing a 50-megawatt VHTR to produce a reducing gas from petroleum refining residues. The hot gases from the reactor would be injected directly into a shaft furnace to directly reduce iron for use in electric furnace steelmaking.[30]

European nuclear steelmaking research was coordinated by the European Nuclear Steelmaking Club (ENSEC), which was established in September 1973. The Club decided initially to pursue the concept of a steelworks separated from the nuclear reactor for generating reducing gases. It was concerned with a high-temperature nuclear reactor to reform hydrocarbons to a reducing gas containing 96% hydrogen for use in blast furnaces, in direct reduction furnaces, and for other industrial uses. Nuclear research in the European countries apparently was guided by the widely divergent energy resources in Europe, which range from natural gas in the North Sea fields to lignite in Germany. A working party of ENSEC in 1976 was making a technical and economic assessment of the various possible total nuclear systems, identifying those upon which future studies should be concentrated.[31]

Direct reduction research was slanted more to application and use of the directly reduced materials than it has been in the past. An international seminar on utilization of prereduced materials in iron and steelmaking was held at Bucharest, Romania, May 24-28, 1976. Forty-six papers from 14 different countries were presented, but only part of the papers dealt with utilization. Those that did covered use of directly reduced materials in electric arc and induction furnaces to produce superior steels, in cupolas for iron castings, and in basic oxygen furnaces for cooling. Other papers dealt with (1) transportation and storage of directly reduced materials, (2) reoxidation and pyrophoric properties, (3) gases used for the reductant, (4) application of direct reduction to lateritic ores containing chromium and nickel, and (5) the present status of direct reduction and its future impact on the iron and steel industries. (These papers are as yet unpublished.)

A study of direct reduction plants in operation, under construction, or in planning stages throughout the world indicated a capacity of 6.6 million tons per year in 1976, rising to 25.5 million tons per year by 1980. Of this capacity, 90% of the reduction would be by gas and 10% by solid fuels; 55% of the reduction would be in shaft furnaces, 33% in retorts, 8.5% in rotary kilns, and 3.5% in fluidized beds.

A theoretical study to improve the blast furnace system based on blast furnace research over the last 25 years was published.[32] The basic parts of the proposed system reportedly had been tested in various parts of the world, but a working unit had yet to be built. The improved system would utilize regulated reducing gas injected above the melting zone of the furnace so that all of the iron oxide would be reduced at the lower temperatures in the upper zone of the furnace. About half the amount of coke per ton of iron produced would be required compared with that needed in the conventional blast furnace, and injection of natural gas or oil would not be required. The reducing gas would be generated in a gas converter from noncoking coal, oil-contaminated mill scale, limestone, basic oxygen furnace and blast furnace top gases and dust residues, moisture, air, and oxygen. Overall cost savings of 10% were estimated.

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[30] Sugeno, T., K. Shimokawa, and K. Tsuruoka. Nuclear Steelmaking in Japan. Iron and Steel Eng., v. 53, No. 11, November 1976, pp. 40-47.

[31] Barnes, R. S. Nuclear Steelmaking in Europe. Iron and Steel Eng., v. 53, No. 5, May 1976, pp. 53-58.

[32] Claflin, H. B. Concepts for an Improved Blast Furnace System. Iron and Steel Eng., v. 53, No. 11, November 1976, pp. 25-29.

Bureau of Mines Research.—Bureau of Mines Report of Investigations 8147, Steel From Urban Waste, described a series of steel heats made by Bureau researchers in a 1-ton arc furnace from ferrous scrap obtained from incinerated refuse, as-received steel cans, and detinned steel cans, both alone and blended with heavy melting scrap. The steel products were cast into ingots and rolled into reinforcing bars. Tensile and bending tests indicated that reinforcing bars of acceptable quality can be made from urban refuse components such as steel cans.[33] The researchers recommended that municipal waste processing systems be designed to avoid excessive oxidation or contamination of the ferrous products and to provide for detinning and baling or fragmentation prior to charging to a steelmaking furnace.

A study conducted for the Bureau of Mines by Battelle Columbus Laboratories based on 1973 data indicated that the energy requirement for production of steel slabs was 24 million British thermal units (Btu) per ton, or a total energy requirement for U.S. steel slab consumption of 3,350 trillion Btu. The energy requirements for gray iron castings were 34 million Btu per ton and 366 trillion Btu total, and for steel castings, 42 million Btu per ton and 54 trillion Btu total.[34]

[33]Hunter, W. L. Steel From Urban Waste. BuMines RI 8147, 1976, 16 pp.

[34]Battelle Columbus Laboratories. Energy Use Patterns in Metallurgical and Non-Metallic Mineral Processing. (Phase 4-Energy Data and Flowsheets, High-Priority Commodities.) BuMines Open File Rep. 80-75, June 27, 1975, 181 pp.; available from National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151, PB 245 759.

Table 2.—Pig iron produced and shipped in the United States, in 1976, by State

(Thousand short tons and thousand dollars)

State	Production	Shipped from furnaces		Average value per ton
		Quantity	Value	
Alabama	3,297	3,276	603,459	$184.21
Illinois	6,429	6,437	1,119,757	173.96
Indiana	17,439	17,461	3,273,078	187.45
Ohio	15,762	15,666	2,856,009	182.31
Pennsylvania	18,007	17,984	3,159,082	175.66
California, Colorado, Utah	4,694	4,692	674,896	143.84
Kentucky, Maryland, Texas, West Virginia	9,472	9,462	1,747,356	184.67
Michigan	7,386	7,385	1,289,209	174.57
New York	4,362	4,330	807,088	186.39
Total	86,848	86,693	15,529,934	179.14

Table 3.—Foreign iron ore and manganiferous iron ore consumed in manufacturing pig iron in the United States, by source of ore

(Thousand short tons)

Source	1975[r] [1]	1976[2]
Australia	841	715
Brazil	2,581	2,546
Canada	754	993
Chile	635	505
Peru	15	10
Venezuela	2,936	3,081
Other countries	1,397	900
Total	9,159	8,750

[r]Revised.
[1]Excludes 15,497,000 tons used in making agglomerates.
[2]Excludes 16,883,000 tons used in making agglomerates.

Table 4.—Pig iron shipped from blast furnaces in the United States, by grade[1]

(Thousand short tons and thousand dollars)

Grade	1975			1976		
	Quantity	Value		Quantity	Value	
		Total	Average per ton		Total	Average per ton
Foundry	6,699	1,130,694	$168.79	8,383	1,560,636	$186.17
Basic	70,072	12,065,060	172.18	75,550	13,464,631	178.22
Bessemer	1,005	176,254	175.38	1,119	210,923	188.49
Low-phosphorus	103	18,500	179.61	102	18,902	185.31
Malleable	998	163,010	163.34	1,208	222,954	184.56
All other (not ferroalloys)	363	53,092	146.26	331	51,888	156.76
Total	79,240	13,606,610	171.71	86,693	15,529,934	179.14

[1]Includes pig iron transferred directly to steel furnaces at same site.

Table 5.—Number of blast furnaces (including ferroalloy blast furnaces) in the United States, by State

State	Jan. 1, 1976			Jan. 1, 1977		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	7	2	9	7	2	9
California	3	1	4	3	1	4
Colorado	4	--	4	3	1	4
Illinois	9	10	19	8	11	19
Indiana	19	8	27	16	11	27
Kentucky	2	--	2	2	--	2
Maryland	7	3	10	3	7	10
Michigan	8	1	9	8	1	9
Minnesota	--	2	2	--	--	--
New York	5	6	11	5	6	11
Ohio	24	15	39	21	18	39
Pennsylvania	25	25	50	22	27	49
Texas	1	1	2	2	--	2
Utah	2	1	3	3	--	3
West Virginia	3	1	4	3	1	4
Total	119	76	195	106	86	192
Ferroalloy blast furnaces	--	1	1	1	--	1
Grand total	119	77	196	107	86	193

Source: American Iron and Steel Institute.

Table 6.—Iron ore and other metallic materials, coke, and fluxes consumed, and pig iron produced in the United States, by State

(Thousand short tons unless otherwise specified)

State	Metalliferous materials consumed: Iron and manganiferous ores: Domestic	Metalliferous materials consumed: Iron and manganiferous ores: Foreign	Metalliferous materials consumed: Agglomerates	Metalliferous materials consumed: Net ores and agglomerates[1]	Metalliferous materials consumed: Net scrap[2]	Metalliferous materials consumed: Miscellaneous[3]	Metalliferous materials consumed: Net total	Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made (short tons): Net ores and agglomerates[1]	Metalliferous materials consumed per ton of pig iron made (short tons): Net scrap[2]	Metalliferous materials consumed per ton of pig iron made (short tons): Miscellaneous[3]	Metalliferous materials consumed per ton of pig iron made (short tons): Total	Coke and fluxes consumed per ton of pig iron (short tons): Net coke	Coke and fluxes consumed per ton of pig iron (short tons): Fluxes
1975:																
Alabama	93	1,524	4,136	5,686	67	26	5,779	2,328	516	3,624	1.569	0.018	0.007	1.595	0.642	0.142
Illinois	348	11	8,018	8,348	162	187	8,697	3,173	660	5,218	1.600	.031	.036	1.667	.608	.126
Indiana	896	W	23,588	24,499	391	1,077	25,968	8,659	1,944	[r]15,658	1.565	.025	.069	1.658	.553	.124
Michigan and Minnesota	245	W	10,567	10,749	367	304	11,420	4,252	967	7,012	1.533	.052	.043	1.629	.606	.138
New York	625	W	4,137	5,205	183	62	5,449	2,265	512	3,299	1.578	.055	.019	1.652	.687	.155
Ohio	2,782	1,316	17,722	21,431	574	927	22,932	9,853	3,063	14,120	1.518	.041	.066	1.624	.698	.217
Pennsylvania	3,785	[r]3,206	20,129	[r]26,578	941	708	[r]28,227	10,737	2,220	17,366	[r]1.530	.054	.041	[r]1.625	.618	.128
California, Colorado, Utah	1,434	W	6,039	7,411	208	89	7,708	2,713	911	4,568	1.622	.046	.019	1.687	.594	.199
Maryland, West Virginia, Kentucky, Texas	358	2,152	11,672	13,721	251	525	14,497	5,456	1,260	[r]8,856	1.549	.028	.059	1.637	.616	.142
Total	10,566	[r]9,160	106,008	[r]123,628	3,144	3,905	[r]130,677	49,436	[4]12,053	79,721	[r]1.551	.039	.049	[r]1.639	.620	.151
1976:																
Alabama	W	1,552	3,990	5,504	45	63	5,612	2,216	450	3,297	1.669	.014	.019	1.702	.672	.136
Illinois	W	4	9,938	10,071	263	249	10,584	3,187	705	6,429	1.566	.041	.039	1.646	.496	.110
Indiana and Michigan	922	428	37,579	38,474	928	1,606	41,008	13,497	2,626	24,825	1.550	.037	.065	1.652	.544	.106
New York	647	W	5,974	6,812	167	108	7,086	2,971	603	4,362	1.562	.038	.025	1.624	.681	.138
Ohio	2,425	1,801	20,099	23,938	359	979	25,276	10,474	3,046	15,762	1.519	.023	.062	1.604	.665	.193
Pennsylvania	2,135	2,953	24,181	28,745	932	707	30,384	10,974	2,102	18,007	1.596	.052	.039	1.687	.609	.117
California, Colorado, Utah	1,561	W	6,233	7,815	173	97	8,085	2,708	904	4,694	1.665	.037	.021	1.722	.577	.193
Maryland, West Virginia, Kentucky, Texas	310	1,555	13,470	14,889	245	502	15,637	5,680	1,028	9,472	1.572	.026	.053	1.651	.600	.109
Total	8,228	8,750	121,464	136,248	3,112	4,311	143,672	51,707	[5]11,464	86,848	1.569	.036	.050	1.654	.595	.132

[r]Revised. W Withheld to avoid disclosing individual company confidential data; included with "Total."
[1]Net ores and agglomerates equal ore plus agglomerates plus flue dust used minus flue dust recovered.
[2]Excludes home scrap produced at blast furnaces.
[3]Does not include recycled material.
[4]Fluxes consisted of the following: 5,103 limestone, 6,671 dolomite, and 280 other fluxes excluding 4,309 limestone, 26 burnt lime, 3,218 dolomite, and 117 other fluxes used in agglomerating production at or near steel plants and an unknown quantity used in making agglomerates at mines.
[5]Fluxes consisted of the following: 4,831 limestone, 209 burnt lime, 6,015 dolomite, and 408 other fluxes excluding 4,384 limestone, 20 burnt lime, 3,835 dolomite, and 68 other fluxes used in agglomerating production at or near steel plants and an unknown quantity used in making agglomerates at mines.

Table 7.—Steel production in the United States, by type of furnace[1]

(Thousand short tons)

Year	Open hearth	Basic oxygen converter	Electric	Total
1972	34,936	74,584	23,721	133,241
1973	39,780	83,260	27,759	150,799
1974	35,499	81,552	28,669	145,720
1975	22,161	71,801	22,680	116,642
1976	23,470	79,918	24,612	128,000

[1]Excludes castings produced by foundries not covered by AISI.

Source: American Iron and Steel Institute.

Table 8.—Metalliferous materials consumed in steel furnaces[1] in the United States

(Thousand short tons)

Year	Iron ore[2]		Agglomerates[2]		Pig iron	Ferro-alloys[3]	Iron and steel scrap
	Domestic	Foreign	Domestic	Foreign			
1972	236	850	401	192	r83,045	1,655	r67,505
1973	163	1,320	656	243	r94,398	1,907	r76,352
1974	153	1,126	272	302	r90,031	1,950	r75,329
1975	92	r515	553	189	r74,518	1,450	r58,071
1976	66	593	584	195	81,926	1,495	63,554

rRevised.
[1]Basic oxygen converter, open-hearth, and electric furnace.
[2]Consumed in integrated steel plants only.
[3]Includes ferromanganese, spiegeleisen, silicomanganese, manganese metal, ferrosilicon, ferrochromium, and ferromolybdenum.

Table 9.—Consumption of pig iron in the United States, by type of furnace or other use

Type of furnace or other use	1974		1975		1976	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Basic oxygen converter	66,614	68.8	59,210	74.3	66,138	76.0
Open hearth	22,507	23.3	14,554	18.3	15,410	17.7
Electric	1,220	1.3	1,019	1.3	638	.7
Cupola	2,123	2.2	1,362	1.7	1,197	1.4
Air and other furnaces[1]	632	.6	483	.6	406	.5
Direct castings[2]	3,696	3.8	3,010	3.8	3,255	3.7
Total	96,792	100.0	79,638	100.0	[3]87,045	100.0

[1]Includes vacuum melting furnaces and miscellaneous melting processes.
[2]Castings made directly from blast furnace hot metal. Includes ingot molds and stools.
[3]Data do not add to total shown because of independent rounding.

Table 10.—Consumption of pig iron[1] in the United States, by State

(Thousand short tons)

State	1976
Alabama	3,125
Arkansas	2
California	2,053
Connecticut	10
Georgia	3
Illinois	6,535
Indiana	17,419
Iowa	30
Kansas	4
Kentucky	1,731
Maine	(2)
Maryland	4,166
Massachusetts	19
Michigan	7,680
Minnesota	32
Missouri	11
Nevada	(2)
New Hampshire	2
New Jersey	20
New York	4,143
North Carolina	9
Ohio	15,490
Oklahoma	6
Oregon	4
Pennsylvania	18,212
Rhode Island	3
Tennessee	49
Texas	764
Utah	1,584
Virginia	90
Washington	1
West Virginia	2,730
Wisconsin	69
Undistributed[3]	1,049
Total	87,045

[1]Includes molten pig iron used for ingot molds and direct castings.
[2]Less than 1/2 unit.
[3]Includes Colorado, Florida, and South Carolina.

Table 11.—U.S. exports of major iron and steel products

Products	1972		1973		1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
SEMIMANUFACTURED										
Ingots and other primary forms:										
Puddled bars and pilings, blocks, lump, other primary forms of iron or steel, n.e.c	543	$107	38	$18	1,223	$653	320	$83	322	$95
Blooms, billets, ingots, slabs, sheet bars, roughly forged pieces	415,392	37,860	546,991	63,023	804,768	147,730	323,320	58,727	260,682	42,063
Coils for rerolling	85,473	13,816	43,702	10,732	149,643	38,760	8,550	4,328	11,607	4,371
Blanks for tubes and pipes, iron or steel	2,807	311	3,737	394	2,654	420	1,628	160	977	82
Total	504,215	52,094	594,468	74,167	958,288	187,563	333,818	63,298	273,588	46,611
Bars, rods, angles, shapes, sections:										
Wire rods	122,894	16,169	89,786	15,308	65,847	17,469	40,616	10,826	112,869	20,949
Bars, rods, hollow-drill steel	166,794	43,735	239,617	70,368	402,996	144,384	174,826	83,264	175,383	74,365
Concrete reinforcing bars	22,417	3,141	151,535	29,788	320,272	86,036	65,323	17,175	2,830	1,313
Angles, shapes, sections	124,825	25,756	272,519	58,708	397,560	109,130	209,998	69,740	121,756	39,824
Plates and sheets:										
Steel plates	15,063	10,262	29,392	17,405	54,791	32,204	29,358	26,923	26,827	25,629
Steel sheets	396,860	66,679	658,430	152,935	1,027,369	293,110	191,943	85,168	309,197	105,066
Black plate	58,831	8,830	95,272	16,344	81,297	18,708	13,086	2,709	28,026	5,101
Iron and steel plates, n.e.c	198,653	42,184	473,911	97,176	536,337	166,602	278,599	101,980	155,277	32,554
Tinplate and terneplate	290,255	55,272	419,275	95,344	500,939	173,742	266,627	109,671	385,484	137,966
Tinplate, circles, cobbles, strip, scroll	4,565	552	24,151	2,678	17,395	2,654	2,837	437	16,843	1,949
Hoop and strip	404,211	76,146	268,762	83,076	394,738	141,894	83,925	62,311	248,493	100,799
Total	1,805,368	348,726	2,722,650	639,125	3,799,541	1,185,933	1,357,138	570,204	1,582,985	545,515
MANUFACTURED										
Rails and railway track construction materials:										
Rails	105,396	16,042	108,965	19,184	128,631	26,221	150,670	45,011	146,892	49,988
Joints and tie plates	9,348	2,173	14,302	3,667	34,610	9,301	43,669	14,509	17,296	5,733
Sleeper and track material of iron or steel, n.e.c	4,767	2,231	4,253	2,044	10,002	5,096	15,177	11,038	5,878	5,857
Wire, cables, ropes, bands, slings	69,819	43,581	88,469	58,639	127,622	98,844	114,932	106,046	130,007	141,402
Tubes, pipes, fittings:										
Cast-iron pressure pipe and fittings	32,586	11,399	27,897	13,575	38,857	29,244	38,635	34,632	33,166	27,168
Cast-iron soil pipe and fittings	4,797	1,744	6,208	2,894	13,358	8,496	39,929	29,719	38,516	28,027
Steel tube and pipe fittings, unions, flanges	17,517	32,001	21,451	40,176	32,055	68,698	30,203	86,498	27,286	96,764

Steel tube and pipe fittings, welded	7,155	14,082	7,621	15,186	12,304	27,668	12,944	42,869	10,881	40,753
Malleable iron tube and pipe fittings, n.e.c	2,282	2,688	3,747	5,449	4,104	5,907	2,300	4,610	3,852	6,451
Electrical conduit fittings of iron or steel	3,907	5,646	4,611	6,710	7,006	10,911	6,548	13,360	9,376	17,540
Iron tube and pipe fittings, n.e.c	8,394	14,535	11,315	20,827	14,150	30,986	19,478	50,427	15,478	41,001
Seamless tubes and pipe	236,633	104,810	376,997	162,263	628,082	513,862	793,638	934,225	371,148	400,871
Welded, clinched or riveted tubes and pipe	187,548	60,504	207,893	77,658	268,353	156,551	255,678	215,608	144,932	117,965
Finished structural iron and steel	89,620	77,989	219,228	153,914	294,345	251,688	220,736	312,554	219,747	356,417
Castings and forgings	371,888	129,629	439,298	173,576	481,091	230,540	407,715	269,923	488,543	348,236
Storage tanks, lined or unlined	14,885	9,628	14,804	11,764	29,826	25,153	19,652	20,879	23,426	29,874
Nails, tacks, staples, spikes, n.e.c	9,045	7,364	12,822	10,928	16,172	14,358	13,740	12,949	15,131	14,882
Bolts	26,062	24,962	31,394	31,677	38,851	44,287	42,800	52,178	48,994	53,911
Nuts	8,845	11,322	10,865	14,613	15,901	22,536	21,740	23,321	23,596	23,930
Screws, rivets, washers	26,401	33,270	32,272	42,850	38,880	58,194	33,859	55,985	40,631	63,511
Total	1,236,895	605,600	1,644,412	867,594	2,234,200	1,638,541	2,284,043	2,336,341	1,814,776	1,870,281
Grand total	3,546,478	1,006,420	4,961,530	1,580,886	6,992,029	3,012,037	3,974,999	2,969,843	3,671,349	2,462,407

Table 12.—U.S. imports for consumption of pig iron, by country

Country	1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Algeria	6,079	$1,381	--	--	--	--
Australia	1,449	184	17,545	$3,038	19,188	$2,858
Belgium-Luxembourg	--	--	111	26	--	--
Brazil	--	--	25,232	2,717	137,582	10,846
Canada	288,955	32,568	224,379	35,393	241,636	33,791
Colombia	7,752	966	1,981	269	--	--
Czechoslovakia	395	9	--	--	--	--
Finland	142	28	--	--	--	--
Germany, West	--	--	5,592	899	--	--
Hungary	17,367	2,733	55,652	9,225	--	--
Japan	--	--	104,085	12,575	27,749	1,573
Norway	--	--	5,512	740	--	--
Sweden	8,298	989	32,201	3,411	8,455	1,013
United Kingdom	11,911	2,180	5,816	1,023	9,672	1,061
Total	342,348	41,038	478,106	69,316	444,282	51,142

Table 13.—U.S. imports for consumption of major iron and steel products

Products	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)	1974 Quantity (short tons)	1974 Value (thousands)	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Iron products:										
Cast iron pipes and tubes	11,870	$3,923	6,248	$1,873	6,593	$3,053	8,264	$3,945	7,906	$5,577
Malleable cast-iron fittings	13,777	7,668	8,493	6,018	6,643	5,765	7,535	6,941	11,136	10,093
Bars of wrought iron	386	120	243	84	390	139	200	94	3	1
Castings and forgings	15,395	6,447	23,059	11,138	35,898	20,371	31,536	21,319	25,832	16,331
Total	41,428	18,158	38,043	19,113	49,524	29,328	47,535	32,299	44,877	32,002
Iron and steel products:										
Ingots, blooms, billets, slabs, sheet bars	261,694	38,242	172,305	30,801	182,859	42,839	242,833	69,333	240,107	52,812
Bars of steel:										
Concrete reinforcement bars	358,223	34,969	286,428	43,875	477,750	137,286	142,232	26,860	192,141	29,944
Solid and hollow steel bars	1,049,173	176,744	954,286	197,426	866,458	301,733	611,503	243,926	575,784	191,262
Hollow drill steel	4,606	1,285	2,637	1,376	2,929	1,819	2,797	2,418	1,746	1,428
Plates and sheets:										
Black plate	2,010	438	3,323	651	8,333	2,352	6,445	1,574	12,596	3,422
Steel plate	1,685,654	239,412	1,348,767	216,255	1,729,001	499,862	1,394,484	404,646	187,429	356,777
Steel sheets	6,959,182	1,043,449	5,837,588	986,676	5,689,737	1,621,105	4,411,404	1,136,183	5,527,122	1,394,298
Plates and sheets of iron or steel	532	441	709	549	527	350	696	1,142	556	916
Plates, sheets and strip of iron or steel[1]	64,179	13,945	71,737	16,976	61,407	21,249	65,002	25,527	66,584	23,018
Strip of iron or steel	135,400	51,850	116,415	52,306	98,058	60,834	71,506	54,690	75,794	47,210
Tinplate and terneplate	522,466	107,870	470,345	105,630	318,996	98,349	408,414	170,191	2,625	895
Structural iron and steel	1,745,696	247,426	1,375,223	228,419	1,229,375	358,640	903,343	274,985	1,433,809	326,115
Angles, shapes, sections	562,864	65,598	457,457	63,044	521,622	156,371	167,284	48,719	309,878	33,332
Wire rods of steel	1,402,904	188,789	1,416,256	229,258	1,950,628	581,611	1,112,794	349,577	1,119,807	288,329
Sheet piling	94,781	12,909	81,248	12,303	84,162	19,295	63,734	17,375	63,088	13,626
Pipes, tubes, fittings	1,887,376	368,846	1,681,112	383,372	1,952,523	748,934	1,778,608	1,021,002	1,958,512	746,004
Bail ties of iron or steel	17,166	3,067	15,334	3,011	27,452	9,530	16,610	6,272	--	--
Steel castings and forgings	24,000	9,186	19,020	7,137	13,555	8,358	15,952	11,953	11,741	7,514
Rails and railway track construction materials	74,820	12,350	77,697	14,741	117,478	34,025	175,418	68,018	32,533	16,046
Wire:										
Round wire	522,205	138,618	525,893	173,701	608,888	317,361	381,289	232,687	380,130	203,702
Other wire	155,770	43,807	87,740	32,217	93,538	55,230	52,265	38,704	70,990	41,254
Nails	379,912	86,572	345,121	97,332	355,815	167,201	220,934	100,267	358,217	139,266
Total	17,910,613	2,885,813	15,346,641	2,897,056	16,391,091	5,244,334	12,245,547	4,306,049	12,621,189	3,917,170
Advanced manufactures:										
Bolts, nuts, rivets, washers	206,428	88,259	223,192	129,043	305,418	309,044	194,779	169,142	430,282	179,961
Grand total	18,158,469	2,992,220	15,607,876	3,045,212	16,746,088	5,582,706	12,487,861	4,507,490	13,096,348	4,129,133

[1]Includes plates, sheets and strips of iron or steel, electrolytically coated or plated; 1972, 58,681 tons ($11,797); 1973, 63,787 tons ($14,020); 1974, 48,945 tons ($14,957); 1975, 56,789 tons ($21,405); 1976, 59,559 tons ($19,852).

Table 14.—Pig iron:[1] World production, by country

(Thousand short tons)

Country[2]	1974	1975	1976[p]
North America:			
Canada	10,386	10,086	10,803
Mexico[3]	[r]3,536	3,265	3,889
United States	95,477	79,721	86,848
South America:			
Argentina	[r]1,177	1,144	1,454
Brazil	[r]6,411	7,774	8,853
Chile	569	459	445
Colombia	297	323	315
Peru	334	332	246
Venezuela	600	589	471
Europe:			
Austria	3,795	3,368	3,658
Belgium	14,352	9,996	10,875
Bulgaria	1,635	1,663	1,716
Czechoslovakia	[r]9,779	10,200	10,411
Finland	1,503	1,495	1,456
France	24,235	19,284	20,569
Germany, East[4]	2,513	2,707	2,787
Germany, West	43,853	32,853	34,765
Greece	551	595	441
Hungary	2,524	2,446	2,448
Italy	12,881	12,512	12,821
Luxembourg[4]	[r]6,028	4,287	4,140
Netherlands	[r]5,296	4,376	4,702
Norway	714	703	713
Poland	8,437	8,381	8,721
Portugal	[r]308	361	378
Romania	6,703	7,277	8,157
Spain	[r]7,610	7,544	7,329
Sweden[3]	[r]3,505	3,854	3,460
Switzerland	39	39	25
U.S.S.R	108,992	112,390	115,086
United Kingdom	[r]15,560	13,600	15,448
Yugoslavia	2,344	2,205	2,114
Africa:			
Algeria	305	440	507
Egypt	303	463	627
Morocco	11	13	[e]13
Rhodesia, Southern[e]	330	340	340
South Africa, Republic of	5,094	5,707	6,390
Tunisia	160	163	119
Asia:			
China, People's Republic of[e] [5]	33,000	35,000	33,000
India	8,093	9,243	10,329
Iran[e]	[r]1,100	1,100	1,100
Israel[e]	[r]44	[r]44	44
Japan	99,690	95,765	95,434
Korea, North[e] [5]	3,100	3,200	3,300
Korea, Republic of	1,088	1,308	2,136
Malaysia[e]	[r]190	[r]200	210
Taiwan	123	74	116
Thailand	[r]19	14	13
Turkey	[r]1,462	1,498	1,680
Oceania:			
Australia	7,992	8,240	8,176
New Zealand[e] [3]	140	220	220
Total	[r]564,188	[r]528,861	549,298

[e]Estimate. [p]Preliminary. [r]Revised.

[1]Table excludes all ferroalloy production except where otherwise noted.

[2]In addition to the countries listed, Vietnam and Zaire have facilities to produce pig iron and may have produced limited quantities during 1974-1977, but output is not reported and available general information is inadequate to permit formulation of reliable estimates of output levels.

[3]Includes sponge iron output as follows in thousand short tons: Mexico: 1974—[r]996; 1975—[r]1,007; 1976—1,229; Sweden: 1974—217; 1975—[r]193; 1976—206; New Zealand, total figure for all years.

[4]May include blast furnace ferroalloys.

[5]Includes ferroalloys.

Table 15.—Raw steel:[1] World production by country

(Thousand short tons)

Country[2]	1974	1975	1976[p]
North and Central America:			
Canada	15,017	14,357	14,480
Cuba[e]	265	[r]265	275
El Salvador	11	12	[e]12
Mexico	5,663	5,812	5,840
United States[3]	145,720	116,642	128,000
South America:			
Argentina	2,595	2,500	2,657
Brazil[4]	[r]8,275	9,158	10,135
Chile	700	538	531
Colombia	367	407	397
Peru	496	476	385
Uruguay	16	18	17
Venezuela	1,166	1,185	1,033
Europe:			
Austria	5,179	4,484	4,935
Belgium	17,890	12,773	13,392
Bulgaria	2,412	2,497	2,712
Czechoslovakia	15,036	15,789	16,196
Denmark	590	616	796
Finland	1,825	1,784	1,812
France	29,788	23,733	25,596
Germany, East	6,796	7,135	7,430
Germany, West	58,678	44,550	46,754
Greece	[r]757	1,102	[e]880
Hungary	3,823	4,049	4,026
Ireland	121	89	64
Italy	26,238	24,070	25,845
Luxembourg	7,108	5,098	5,033
Netherlands	[r]6,412	5,289	5,701
Norway	1,054	1,000	990
Poland	[r]16,045	16,542	17,240
Portugal	427	462	511
Romania	[r]9,753	10,526	11,905
Spain	[r]12,647	12,253	12,024
Sweden	6,602	6,186	5,666
Switzerland	[r]654	463	601
U.S.S.R	[r]150,141	155,784	159,620
United Kingdom	24,720	22,264	24,552
Yugoslavia	3,126	3,215	3,032
Africa:			
Algeria	[r]275	332	[e]385
Egypt	[e] [r]440	384	504
Morocco[e]	[r]6	[r]6	6
Rhodesia, Southern[e]	300	330	330
South Africa, Republic of	[r]6,354	7,163	7,807
Tunisia	145	143	113
Uganda[e]	[r]13	17	13
Asia:			
Bangladesh	[r]89	107	96
Burma[e]	[r]45	[r]45	45
China, People's Republic of[e]	30,000	32,000	30,000
Hong Kong[e]	80	80	80
India	[r]7,518	7,807	10,429
Indonesia	88	110	[e]110
Iran	[r]625	607	772
Israel[e]	[r]85	[r]70	80
Japan	129,115	112,780	118,387
Korea, North[e]	3,000	3,200	3,300
Korea, Republic of	2,133	2,215	2,974
Lebanon[e]	17	17	11
Malaysia	[r]202	215	[e]220
Philippines[e]	308	276	287
Singapore[e]	240	240	250
Taiwan	628	573	658
Thailand	243	260	180
Turkey	1,608	1,607	1,601
Oceania:			
Australia	8,548	8,645	8,569
New Zealand	214	204	[e]210
Total	[r]780,432	[r]712,556	748,492

[e]Estimate. [p]Preliminary. [r]Revised.

[1]Steel formed in first solid state after melting, suitable for further processing or sale.

[2]In addition to the countries listed, Vietnam produces steel, but output is not reported and available general information is inadequate to permit formulation of reliable estimates of output levels.

[3]Data from American Iron and Steel Institute (AISI). Excludes steel produced by foundries not reporting output to AISI but reported to Bureau of the Census as follows (in thousand short tons): 1974—2,091; 1975—[r]1,937; 1976—1,804.

Iron and Steel Scrap

By K. W. Palmer[1]

Reflecting the general improvement in the economy, domestic consumption of iron and steel scrap in 1976 increased 9% compared with that of 1975. Net receipts of scrap by users were 13% above those for 1975, while yearend stocks increased 14% to 10 million tons.[2]

January's consumption (close to the 6.9-million-ton monthly average for 1975) was followed by an increase to 8.4 million tons in May. Consumption then fell irregularly to the year's low of 6.7 million tons in December.

Reported consumption of direct-reduced iron (prereduced iron ore), used as a scrap substitute by some of the smaller steelworks and foundries was 351,000 tons, about 32% less than in 1975. The decline was mainly due to the relatively low prices for ferrous scrap in 1976.

U.S. exports of scrap were 17% less than in 1975, reflecting the depressed condition of the world steel market. For the first time, shredded scrap was the principal grade exported.

The domestic scrap industry continued to seek lower rail freight rates. Pending results of an investigation of rate structures by the Interstate Commerce Commission (ICC), the scrap industry was temporarily exempted from a 4% increase in freight rates authorized at yearend for other commodities.

Research was continued by the Bureau of Mines on treatment of urban waste and junk automobiles for scrap recovery with the eventual aim of recycling as much as feasible.

Legislation and Government Programs.—Public Law 94-210 (Railroad Revitalization and Regulatory Reform Act of 1976) became effective in February 1976. The law charged the ICC to investigate within 12 months the railroads' rate structure and its effect on the ultimate usage of "recyclable or recycled materials and competing virgin natural resource materials." The ICC on its own initiative started such an investigation in 1973 under

[1]Physical scientist, Division of Ferrous Metals.
[2]All tonnages are in short tons unless otherwise noted.

Table 1.—Salient iron and steel scrap and pig iron statistics in the United States

(Thousand short tons and thousand dollars)

	1975	1976
Stocks Dec. 31:		
Scrap at consumer plants	8,766	9,988
Pig iron at consumer and supplier plants	1,435	1,519
Total	10,201	11,507
Consumption:		
Scrap	82,331	89,910
Pig iron	79,638	87,045
Exports:		
Scrap (excludes rerolling material and ships, boats, and other vessels for scrapping)	9,442	7,877
Value	$762,976	$601,826
Imports for consumption:		
Scrap (includes tinplate and terneplate scrap)	305	507
Value	$25,250	$35,120

Ex-Parte 270-6 which was completed in March 1976. The ICC rejected the ferrous scrap industry's allegations of rate discrimination by the railroads, stating that scrap and iron ore are "in almost all cases complementary and not competitive." At yearend the report required by Public Law 94-210, due by February 5, 1977, was being assembled.

On December 22 the ICC granted a 4% increase in freight rates to the Nation's railroads but temporarily exempted the recycling industry. The new rates were to be in effect not earlier than January 7, 1977.

On October 20 the President signed into law an act authorizing a 6-month study by the Department of the Treasury in cooperation with the Environmental Protection Agency (EPA) on tax incentives for recycling waste materials. The Department was to study tax provisions which "currently impede or discourage the recycling of solid waste materials" as well as to determine what actions Congress may take under the internal revenue laws to increase and encourage the recycling of solid waste materials.

AVAILABLE SUPPLY

The new supply of iron and steel scrap, available for consumption at consumers' plants in 1976, totaled 91.4 million tons. It consisted of 50 million tons of home scrap and 41.4 million tons of purchased scrap (net receipts). These quantities were both 11% higher than those of 1975.

CONSUMPTION

Consumption of iron and steel scrap in 1976 was 89.9 million tons, or 9% more than in 1975. Manufacturers of pig iron, steel ingots, and castings consumed 68.4 million tons (76%); iron foundries and miscellaneous users consumed 18.6 million tons (21%); and steel foundries consumed the remainder.

The proportion of shredded scrap consumed domestically or exported declined from 6.3% to 5.8% of total scrap consumption. Ohio consumers accounted for 17% of total consumption of shredded scrap, followed by Illinois (15%) and Michigan (11%).

STOCKS

Consumers' stocks reported on hand as of December 31, 1976, totaled 10 million tons or 14% more than those at yearend 1975. The increase resulted from a slow climb in stocks until June, after which the raw steel production rate dropped and stocks of scrap accumulated more rapidly. Yearend stocks were the highest since 1959.

PRICES

At approximately $70 per long ton, the composite price for steel scrap at the end of 1976 was almost the same as that at the beginning of the year. The Iron Age weekly composite price for No. 1 heavy melting scrap rose from $68.17 per long ton on January 2 to a 1976 high in early April of $94.83, then declined irregularly to a low of $62.83 on November 1, recovering to $70.17 at yearend. This resulted in an average annual price for No. 1 heavy melting scrap of $77.79, 8% above the average price of $71.86 for 1975. These price trends were reflected in prices of other grades of ferrous scrap.

FOREIGN TRADE

Exports of iron and steel scrap, excluding rerolling material and vessels for scrapping, amounted to 7.9 million tons in 1976, 16% less than the 9.4 million tons exported in 1975. The decline reflected the depressed condition of the steel industries of the major scrap importing countries with the exception of the Republic of Korea.

Spain replaced Japan as the largest importer of U.S. scrap, taking 23% of the total in 1976. Japan was the second largest importer, receiving 15%, the lowest tonnage received since 1958. The third largest importer was the Republic of Korea, with 12%, followed by Canada with 11%.

For the first time, shredded and fragmentized steel scrap (27% of total exports) replaced No. 1 heavy melting steel scrap (26% of scrap exports) as the leading export grade.

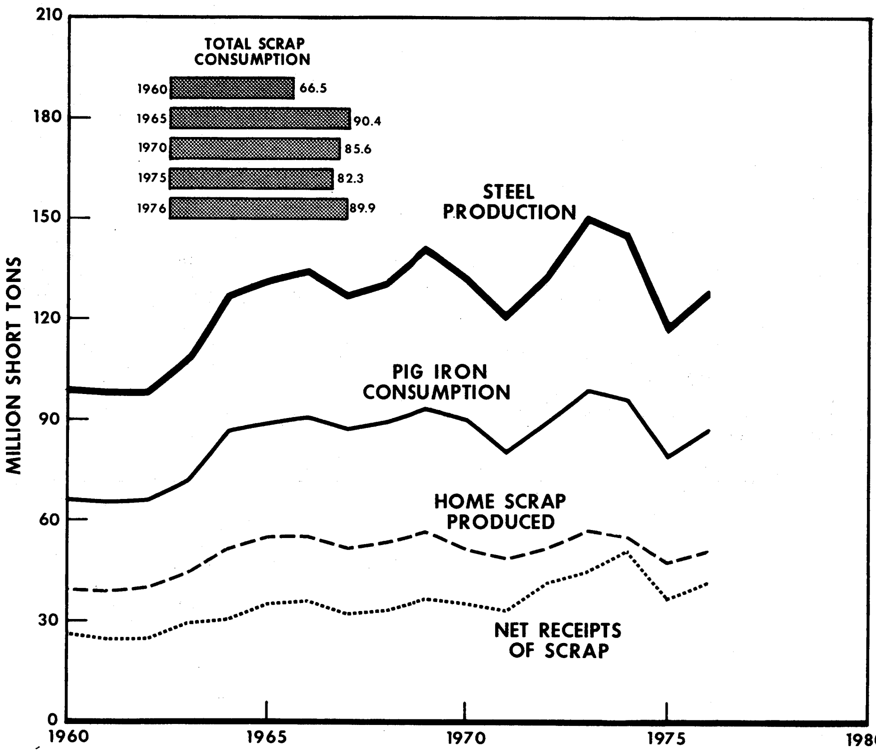

Figure 1.—Steel production (AISI), total iron and steel scrap consumption, pig iron consumption, home scrap production, and net scrap receipts.

WORLD REVIEW

Apparent world consumption of ferrous scrap in 1976, as estimated from data available for the principal consuming countries, appeared to increase about 6% compared with apparent consumption in 1975. The increase was approximately proportional to the rise in world output of raw steel. The United States remained the largest exporter of iron and steel scrap to world markets in 1976, while Italy was the leading importer.

Preliminary statistics on apparent consumption and prices of ferrous scrap in the principal consuming countries in 1976 are summarized below.

Country	Raw steel production[1] (million short tons)	Iron and steel scrap: Apparent consumption[1 2] (million short tons)	Iron and steel scrap: Average 1976 price (dollars per long ton)[3]
U.S.S.R.	162.0	93.5	NA
United States	128.0	90.0	$77.79
Japan	118.5	42.0	99.50
Germany, West	47.0	19.5	82.30
China, People's Republic of	[e]28.5	[e]5.0	NA
Italy	26.0	16.0	64.10
France	25.5	11.0	71.60
United Kingdom	25.0	17.5	60.46
Poland	17.5	[e]11.5	NA
Czechoslovakia	16.0	8.0	NA
Canada	14.5	8.0	--
Belgium	13.5	5.0	[4]80.00
Spain	12.0	8.0	59.50
Total listed	634.0	335.0	--

[e]Estimate. NA Not available.
[1]Rounded to nearest 500,000 tons.
[2]Including consumption in foundries, except for the People's Republic of China.
[3]Grade of scrap approximately equivalent to U.S. No. 1 heavy melting.
[4]Average of high and low figures.

Sources: American Iron and Steel Institute (AISI). Annual Statistical Report, 1976. International Iron and Steel Institute (IISI). World Steel in Figures, 1977. Bureau International de la Recuperation (BIR), (Brussels). Reports on the national markets, April 1977. Embassy of Canada, Washington, D. C. (personal communication). Economic Commission for Europe (ECE) Steel Committee. Sumitomo Shoji (personal communication).

Relationships between apparent consumption of scrap and production of raw steel continued to differ rather widely from country to country because of differences in metallurgical practice, magnitude of foundry consumption, availability of scrap, and other factors. For example, relatively large proportions of the raw steel output of Italy and Spain were produced from scrap in electric furnaces, whereas steel produced in France and Japan was made largely in converters using hot metal and relatively low proportions of scrap. Foundry consumption of scrap in the United States and the United Kingdom was proportionately larger than in most other countries. Consumption of scrap in the U.S.S.R. appeared to be relatively low, partly because of the extensive use of pig iron in open-hearth furnaces.

In world trade, France exported 3 million tons of scrap in 1976 and was the leading exporter outside of the United States. Net exports of scrap by West Germany and the U.S.S.R. amounted to about 1 million tons each. Imports of scrap by Italy totaled 5.9 million tons, with France being the largest supplier. Spain imported 2.9 million tons and Japan 2 million tons with 63% to 64% in each country coming from the United States. The United Kingdom, which had been a small net exporter of scrap in 1974 and 1975, became a net importer in 1976 with 507,000 tons imported from the United States.

Japanese imports of ferrous scrap in 1976 dropped to the lowest level since the 1950's. Japanese steel production, which was well below capacity in 1976, had started to decline in the first half of 1975, but imports of scrap were not reduced appreciably until November of that year. Consequently, there was an accumulation of scrap stocks which depressed demand for scrap imports in 1976. This was also the first year since the early 1950's that Japan was not the leading importer of scrap from the United States.

In other developments, the British Steel Corp. (BSC) continued its policy of designating less than 20 British firms as direct suppliers of scrap to the corporation. This policy aroused much criticism from the British Scrap Federation (BSF), the majority of whose members were not allowed to deal directly with BSC. Since most BSF members were not large-volume dealers and could not take advantage of potential economies of scale, the drop in average scrap prices in the United Kingdom (from $76.70 per short ton in 1974 to $54.00 per short ton in 1976) resulted in financial difficulties for many of these firms.

TECHNOLOGY

Many orders for automobile shredders were placed prior to 1975 when the market outlook for scrap was more favorable. This resulted in long lead times for delivery so that, despite a generally weak scrap market in 1976, the number of shredders installed rose to 157 by yearend and resulted in over capacity.[3] Shredded scrap consumed domestically or exported in 1976 totaled 5.2 million tons or 0.5% more than in 1975.

In the scrap-handling equipment field, a motor puller for automobile hulks that would fit most front-end loaders has been developed. There was also a trend in equipment purchases during 1976 toward smaller balers and larger shears, but no noticeable trend was noted in size of shredders.

At the beginning of 1976, only one scrap dealer operated a hot briquetter for borings and turnings. During the year, two more briquetters came onstream. Four additional hot briquetters were planned or ordered by other companies during the year.[4]

Toll arrangements for briquetting other companies' scrap were reported in 1976; these have been rare in the ferrous scrap trade. A few small steel mills were installing scrap processing equipment such as shredders and briquetters.

A study by A. T. Kearney Inc., a Chicago consulting firm under contract to the Bureau of Mines, estimated U.S. geographical distribution of newly available ferrous scrap supply and demand from 1975 through 1985. The study indicated that the net balance between the total supply of newly available ferrous scrap and total domestic demand for consumption would be positive, although small, for all but 2 years; these 2 years would have a small negative balance.[5] Another study contracted for by the Bureau of Mines in 1975 for a period of 2 years was concerned with the identification of legal and regulatory barriers to the expanded use of secondary ferrous and nonferrous metals. It was to be completed and a report issued by mid-1977.

Several resource recovery facilities to separate ferrous scrap from refuse came onstream in 1976. By yearend there were nine operational facilities with a total refuse processing capacity of 8,570 tons per day. In addition, seven facilities with a total processing capacity of 8,950 tons per day were under construction.

At the Bureau of Mines Salt Lake City Metallurgy Research Center, research was continued to develop or improve methods for reclaiming plastics or vinyl-free combustible materials from shredded junk automobile rejects, and to recover and separate nonferrous metals and nonmetals contained in such rejects. Late-model cars were dismantled to determine the amounts and types of construction materials present and to ascertain the plastics content of the cars.

At the Bureau's Twin Cities Metallurgy Research Center, ferrous scrap from raw refuse was successfully used as 60% of the charge in a basic-lined cupola, with shredded automobile scrap as the remainder of the charge. Tests prior to 1976 were made with a maximum of 35% scrap from raw refuse. Cupola tests were also conducted using 25% to 100% direct-reduced iron pellets with automobile scrap as the remainder of the charge and 25% to 50% direct-reduced pellets with raw refuse scrap as the rest of the charge.

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[3] Scrap Age. Exclusive Survey of Automobile Shredding. V. 5, No. 3, March 1977, p. 43.

[4] American Metal Market. Market Widens for Her Hot Briquetters. V. 83, No. 149, July 30, 1976, p. 14.

[5] A.T. Kearney, Inc. Ferrous Scrap Geographical Distributions Demand vs. Newly Available Supply, 1975-1985. BuMines Open File Rept. 97-76, 1976, 162 pp; available from NTIS, PB 257 481/AS, $6.75.

Table 2.—U.S. consumer receipts, production, consumption, shipments and stocks of iron and steel scrap in 1976, by grade

(Thousand short tons)

Grade of scrap	Receipts of scrap: From brokers, dealers, and other outside sources	Receipts of scrap: From other own-company plants	Production of home scrap: Recirculating scrap resulting from current operations	Production of home scrap: Obsolete scrap (includes ingot molds, stools, and scrap from old equipment, obsolete buildings, etc.)	Consumption of both purchased and home scrap (includes recirculating scrap)	Shipments of scrap	Ending stocks Dec. 31
MANUFACTURERS OF PIG IRON AND STEEL INGOTS AND CASTINGS[1]							
Carbon steel:							
Low-phosphorus plate and punchings	852	9	171	1	987	18	141
Cut structural and plate	229	2	206	7	393	44	32
No. 1 heavy melting steel	5,462	3,130	18,030	111	23,984	2,856	2,577
No. 2 heavy melting steel	2,333	83	1,187	2	3,421	67	529
No. 1 and electric furnace bundles	6,335	514	2,667	13	8,870	25	1,615
No. 2 and all other bundles	2,290	93	340	--	2,584	135	349
Electric furnace 1 foot and under (not bundles)	143	--	73	--	184	(2)	32
Railroad rails	62	1	(2)	2	64	1	1
Turnings and borings	1,024	73	338	1	1,339	76	106
Slag scrap (Fe content 70%)	1,220	173	2,910	26	4,180	130	316
Shredded or fragmentized	1,580	532	6	--	2,064	30	161
All other carbon steel scrap	2,586	150	10,735	387	12,685	799	1,012
Stainless steel scrap	391	32	602	(2)	1,020	44	85
Alloy steel (except stainless)	164	206	1,538	9	1,829	122	273
Ingot mold and stool scrap	402	730	874	2,025	3,055	817	1,039
Machinery and cupola cast iron	13	--	--	--	10	--	2
Cast iron borings	218	117	393	20	690	78	77
Motor blocks	15	--	(2)	--	15	(2)	1
Other iron scrap	330	133	610	20	752	350	153
Other mixed scrap	181	52	158	1	301	115	87
Total scrap[3]	25,830	6,030	40,840	2,624	68,427	5,709	8,589
MANUFACTURERS OF STEEL CASTINGS[4]							
Carbon steel:							
Low-phosphorus plate and punchings	589	8	190	1	778	(2)	86
Cut structural and plate	189	23	23	(2)	230	1	22
No. 1 heavy melting steel	134	4	73	--	211	1	29
No. 2 heavy melting steel	43	(2)	13	--	56	--	4
No. 1 and electric furnace bundles	58	(2)	(2)	--	58	1	4
No. 2 and all other bundles	4	--	--	--	4	--	1

Electric furnace 1 foot and under (not bundles)	54	1	15	--	68	1	6
Railroad rails	(2)	(2)	--	--	(2)	--	(2)
Turnings and borings	50	5	30	--	81	7	4
Slag scrap (Fe content 70%)	5	--	7	--	11	(2)	(2)
Shredded or fragmentized	86	11	(2)	(2)	96	--	7
All other carbon steel scrap	426	29	331	11	802	2	41
Stainless steel scrap	22	7	25	1	51	4	6
Alloy steel (except stainless)	60	14	138	(2)	173	17	22
Ingot mold and stool scrap	4	--	(2)	--	4	1	(2)
Machinery and cupola cast iron	11	(2)	14	(2)	23	(2)	2
Cast iron borings	39	(2)	51	--	91	(2)	3
Motor blocks	1	--	--	--	1	--	(2)
Other iron scrap	47	1	65	2	108	4	21
Other mixed scrap	1	--	4	--	5	--	(2)
Total scrap[3]	1,821	104	979	15	2,851	40	259
IRON FOUNDRIES AND MISCELLANEOUS USERS							
Carbon steel:							
Low-phosphorus plate and punchings	743	128	98	(2)	965	13	67
Cut structural and plate	1,359	111	129	4	1,588	7	95
No. 1 heavy melting steel	292	130	67	(2)	412	56	60
No. 2 heavy melting steel	103	5	18	(2)	134	(2)	7
No. 1 and electric furnace bundles	164	217	50	1	424	1	11
No. 2 and all other bundles	344	82	10	--	437	1	35
Electric furnace 1 foot and under (not bundles)	378	111	10	--	492	--	14
Railroad rails	108	(2)	(2)	--	102	(2)	12
Turnings and borings	799	109	16	1	750	32	107
Slag scrap (Fe content 70%)	39	--	1	--	39	1	6
Shredded or fragmentized	732	122	7	(2)	839	(2)	42
All other carbon steel scrap	1,071	837	128	1	2,032	16	123
Stainless steel scrap	11	(2)	4	(2)	20	(2)	4
Alloy steel (except stainless)	68	1	6	1	73	2	13
Ingot mold and stool scrap	142	(2)	98	6	237	9	28
Machinery and cupola cast iron	943	129	706	5	1,751	16	88
Cast iron borings	574	691	273	1	1,452	52	99
Motor blocks	636	41	388	(2)	1,068	1	56
Other iron scrap	1,061	89	3,253	12	4,275	121	180
Other mixed scrap	434	893	270	6	1,541	5	93
Total scrap[3]	10,000	3,698	5,529	38	18,632	334	1,141
TOTAL—ALL TYPES OF MANUFACTURERS							
Carbon steel:							
Low-phosphorus plate and punchings	2,183	145	460	2	2,730	31	293
Cut structural and plate	1,777	137	358	11	2,211	52	149
No. 1 heavy melting steel	5,888	3,265	18,170	111	24,606	2,913	2,666
No. 2 heavy melting steel	2,479	88	1,218	3	3,612	68	539

See footnotes at end of table.

Table 2.—U.S. consumer receipts, production, consumption, shipments and stocks of iron and steel scrap in 1976, by grade —Continued

(Thousand short tons)

Grade of scrap	Receipts of scrap: From brokers, dealers, and other outside sources	Receipts of scrap: From other own-company plants	Production of home scrap: Recirculating scrap resulting from current operations	Production of home scrap: Obsolete scrap (includes ingot molds, stools, and scrap from old equipment, obsolete buildings, etc.)	Consumption of both purchased and home scrap (includes recirculating scrap)	Shipments of scrap	Ending stocks Dec. 31
TOTAL—ALL TYPES OF MANUFACTURERS —Continued							
Carbon steel —Continued							
No. 1 and electric furnace bundles	6,556	730	2,716	13	9,352	26	1,631
No. 2 and all other bundles	2,637	176	350	--	3,025	137	384
Electric furnace 1 foot and under (not bundles)	575	112	98	--	744	1	52
Railroad rails	170	1	1	2	166	2	14
Turnings and borings	1,873	186	384	3	2,171	115	217
Slag scrap (Fe content 70%)	1,264	173	2,917	26	4,231	131	322
Shredded or fragmentized	2,398	665	13	([2])	2,999	30	210
All other carbon steel scrap	4,082	1,017	11,194	398	15,519	818	1,176
Stainless steel scrap	424	39	632	1	1,091	48	95
Alloy steel (except stainless)	293	221	1,681	10	2,075	141	308
Ingot mold and stool scrap	547	730	973	2,031	3,297	827	1,068
Machinery and cupola cast iron	968	130	720	5	1,784	16	93
Cast iron borings	830	809	717	21	2,232	130	180
Motor blocks	652	41	388	([2])	1,084	2	57
Other iron scrap	1,438	223	3,927	34	5,136	474	354
Other mixed scrap	616	945	432	7	1,848	120	180
Total scrap[3]	37,650	9,832	47,349	2,677	89,910	6,083	9,988

[1]Includes only those castings made by companies producing steel ingots.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.
[4]Excludes companies that produce both steel ingots and steel castings.

Table 3.—U.S. consumer receipts, production, consumption, shipments, and stocks of pig iron and direct-reduced iron in 1976

(Thousand short tons)

	Receipts	Production	Consumption	Shipments	Stocks Dec. 31
MANUFACTURERS OF PIG IRON AND STEEL INGOTS AND CASTINGS					
Pig iron	5,522	86,849	84,214	8,064	1,381
MANUFACTURERS OF STEEL CASTINGS					
Pig iron	46	--	46	(1)	7
IRON FOUNDRIES AND MISCELLANEOUS USERS					
Pig iron	2,770	--	2,785	13	131
TOTAL—ALL TYPES OF MANUFACTURERS					
Pig iron	8,338	86,849	87,045	8,077	1,519
Direct-reduced or prereduced iron	356	--	351	W	4

W Withheld to avoid disclosing individual company confidential data.
[1]Less than 1/2 unit.

Table 4.—Consumption of iron and steel scrap and pig iron in the United States in 1976, by type of consumer and type of furnace, or other use

(Thousand short tons)

Type of furnace or other use	Manufacturers of pig iron and steel ingots and castings		Manufacturers of steel castings		Iron foundries and miscellaneous users		Total all types[1]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Blast furnace[2]	3,692	--	--	--	--	--	3,692	--
Basic oxygen process[3]	26,204	66,138	--	--	--	--	26,204	66,138
Open-hearth furnace	12,251	15,405	87	6	--	--	12,337	15,410
Electric furnace	25,099	383	2,613	35	4,590	220	32,301	638
Cupola furnace	405	194	127	1	12,808	1,002	13,341	1,197
Other (including air furnace)[4]	776	357	24	4	1,235	45	2,035	406
Direct castings[5]	--	1,736	--	--	--	1,519	--	3,255
Total[1]	68,427	84,214	2,851	46	18,632	2,785	89,910	87,045

[1]Data may not add to totals shown because of independent rounding.
[2]Includes consumption in all blast furnaces producing pig iron.
[3]Includes scrap and pig iron processed in metallurgical blast cupolas and used in oxygen converters.
[4]Includes vacuum melting furnaces and miscellaneous uses.
[5]Includes ingot molds and stools.

Table 5.—Proportion of iron and steel scrap and pig iron used in furnaces in 1976 in the United States

(Percent)

Type of furnace	Scrap	Pig iron
Basic oxygen process	28.4	71.6
Open-hearth furnace	44.5	55.5
Electric furnace	98.1	1.9
Cupola furnace	91.8	8.2
Other (including air furnace)	83.4	16.6

Table 6.—Iron and steel scrap supply[1] available for consumption in 1976, by State and region

(Thousand short tons)

State and region	Receipts of scrap: From brokers, dealers, and other outside sources	Receipts of scrap: From other own-company plants	Productions of home scrap: Recirculating scrap resulting from current operations	Productions of home scrap: Obsolete scrap (includes ingot molds, stools, and scrap from old equipment, buildings, etc.)	Total new supply[2]	Shipments of scrap[3]	New supply available for consumption
New England and Middle Atlantic:							
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont	1,596	228	1,917	48	3,788	158	3,630
Pennsylvania	5,261	2,175	10,253	705	18,395	2,149	16,246
Total[2]	6,857	2,402	12,170	753	22,182	2,307	19,875
North Central:							
Illinois	4,502	1,087	3,880	245	9,714	276	9,438
Indiana	2,653	127	8,378	475	11,633	1,115	10,518
Michigan, Iowa, Minnesota, Nebraska, Kansas, Missouri	6,312	2,904	4,146	468	13,830	248	13,583
Ohio	5,526	1,870	7,909	311	15,617	942	14,675
Wisconsin	684	46	541	1	1,273	20	1,253
Total[2]	19,678	6,034	24,854	1,501	52,067	2,600	49,467
South Atlantic:							
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	2,997	253	3,298	224	6,773	57	6,716
South Central:							
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	5,460	690	4,366	94	10,610	932	9,678
Mountain and Pacific:							
Arizona, California, Colorado, Montana, Nevada, Oregon, Utah, Washington	2,659	453	2,660	105	5,876	187	5,689
U.S. total[2]	37,650	9,832	47,349	2,677	97,508	6,083	91,425

[1]New supply available for consumption is a net figure computed by adding production to receipts and deducting scrap shipped during the year. The plus or minus difference in stock levels at the beginning and end of year is not taken into consideration.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes scrap shipped, transferred, or otherwise disposed of during the year.

Table 7.—Consumption of iron and steel scrap and pig iron[1] by State and region, by type of manufacturer in 1976

(Thousand short tons)

State and region	Pig iron and steel ingots and castings		Steel castings		Iron foundries and miscellaneous users		Total[2]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
New England and Middle Atlantic:								
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont	2,071	3,853	151	4	1,117	340	3,340	4,197
Pennsylvania	15,164	17,611	336	16	799	585	16,299	18,212
Total[2]	17,235	21,464	487	20	1,917	925	19,638	22,409
North Central:								
Illinois	7,002	6,202	418	1	1,730	332	9,151	6,535
Indiana	9,363	17,302	210	1	882	116	10,455	17,419
Michigan, Iowa, Minnesota, Nebraska, Kansas, Missouri	6,580	7,260	391	2	6,223	495	13,194	7,757
Ohio	11,356	14,922	250	13	2,909	555	14,516	15,490
Wisconsin	--	--	275	1	979	68	1,254	69
Total[2]	34,301	45,686	1,544	17	12,724	1,567	48,569	47,269
South Atlantic:								
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	5,644	6,884	66	1	781	120	6,491	7,005
South Central:								
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	6,638	5,523	388	3	2,492	151	9,518	5,677
Mountain and Pacific:								
Arizona, California, Colorado, Montana, Nevada, Oregon, Utah, Washington	4,610	4,657	365	5	718	23	5,694	4,684
U.S. total[2]	68,427	84,214	2,851	46	18,632	2,785	89,910	87,045

[1]Includes molten pig iron used for ingot molds and direct castings.
[2]Data may not add to totals shown because of independent rounding.

Table 8.—Consumer stocks of iron and steel scrap, by grade, and pig iron, Dec. 31, 1976, by State and region

(Thousand short tons)

State and region	Carbon steel (excludes rerolling rails)	Stainless steel	Alloy steel (excludes stainless)	Cast iron (includes borings)	Other grades of scrap	Total scrap stocks[1]	Pig iron stocks
New England and Middle Atlantic:							
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont	567	15	19	172	9	783	180
Pennsylvania	1,348	39	130	396	3	1,916	293
Total[1]	1,915	54	149	568	12	2,698	473
North Central:							
Illinois	1,055	9	6	75	(2)	1,145	26
Indiana	755	3	52	373	72	1,255	62
Michigan, Iowa, Minnesota, Nebraska, Kansas, Missouri	835	10	1	180	68	1,094	45
Ohio	1,051	8	56	186	3	1,304	520
Wisconsin	25	1	(2)	11	(2)	38	8
Total[1]	3,721	31	116	825	143	4,837	661
South Atlantic:							
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	463	7	10	82	2	562	46
South Central:							
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	1,045	1	26	179	21	1,271	300
Mountain and Pacific:							
Arizona, California, Colorado, Montana, Nevada, Oregon, Utah, Washington	509	2	7	98	2	619	38
U.S. total[1]	7,652	95	308	1,752	180	9,988	1,519

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 9.—Average monthly price and composite price for No. 1 heavy melting scrap in 1976

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price[1]
January	$73.75	$74.50	$68.25	$72.16
February	75.75	80.00	78.50	78.08
March	89.90	87.10	90.10	89.03
April	93.75	91.00	90.50	91.75
May	85.25	83.00	83.00	83.75
June	86.90	84.70	81.90	84.50
July	89.50	88.00	84.50	87.33
August	79.30	80.70	78.70	79.56
September	70.00	73.00	68.25	70.41
October	61.75	66.50	63.75	64.00
November	64.10	64.70	62.50	63.77
December[e]	67.00	73.00	67.75	69.25
Average 1976[e]	78.07	78.85	76.47	77.79
Average 1975[r]	71.42	70.20	73.97	71.86

[e]Estimate. [r]Revised.
[1]Composite price, Chicago, Pittsburgh, and Philadelphia.

Source: Iron Age, Jan. 3, 1977.

Table 10.—U.S. exports and imports for consumption of iron and steel scrap, by class

(Thousand short tons and thousand dollars)

Class	1972		1973		1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Exports:										
No. 1 heavy melting scrap	2,289	79,246	3,780	207,743	2,565	262,810	2,766	233,784	2,063	150,327
No. 2 heavy melting scrap	756	23,200	1,107	52,817	883	84,826	1,102	85,508	705	46,047
No. 1 bundles	180	6,112	391	21,565	78	8,504	120	9,574	95	7,726
No. 2 bundles	897	19,623	1,221	49,421	1,304	99,652	1,159	71,903	845	48,144
Stainless steel scrap	48	11,679	49	16,731	35	15,351	66	27,463	112	52,516
Shredded steel scrap	1,463	48,186	2,098	118,133	1,999	225,990	2,406	206,691	2,179	164,922
Borings, shovelings, and turnings	508	10,761	521	16,352	544	35,404	597	29,721	644	32,339
Other steel scrap[1]	597	21,562	1,102	57,528	463	40,814	726	63,565	760	65,809
Iron scrap	439	13,026	605	29,721	626	50,369	500	34,767	474	33,996
Total	7,177	233,395	10,874	570,011	8,497	823,720	9,442	762,976	7,877	601,826
Ships, boats, and other vessels (for scrapping)	299	9,009	156	8,056	327	33,140	40	1,742	50	2,280
Rerolling material	207	10,213	382	28,489	199	25,025	160	16,266	241	32,652
Total	7,683	252,617	11,412	606,556	9,023	881,885	9,642	780,984	8,168	636,758
Imports:										
Iron and steel scrap	295	14,304	337	18,716	188	26,166	293	24,464	496	34,524
Tinplate scrap	17	437	12	384	13	861	12	786	11	596
Total	312	14,741	349	19,100	201	27,027	305	25,250	507	35,120

[1]Includes terneplate and tinplate.

Table 11.—U.S. exports of iron and steel scrap, by country

(Thousand short tons and thousand dollars)

Country	1972		1973		1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	231	7,857	261	13,840	148	16,189	332	29,110	77	5,746
Belgium-Luxembourg	5	300	3	535	(1)	105	16	1,813	9	3,603
Brazil	61	2,174	5	229	27	3,321	7	1,025	(1)	332
Canada	903	26,605	811	27,097	940	52,296	873	44,676	889	48,140
Chile	5	417	15	1,255	23	2,828	(1)	2	14	1,138
China, People's Republic of	--	--	428	23,729	189	12,406	175	13,243	52	4,192
Egypt	--	--	--	--	15	1,611	34	2,660	41	2,820
France	(1)	5	30	2,682	16	4,019	7	1,325	3	306
Germany, West	7	473	2	283	4	1,481	14	6,027	27	8,320
Greece	163	4,893	187	9,429	113	12,762	161	12,964	222	17,475
Hong Kong	1	277	1	231	1	83	1	207	1	339
Israel	--	--	(1)	6	27	2,857	15	1,134	89	7,242
Italy	717	23,222	353	23,966	485	58,896	613	57,548	634	57,489
Japan	2,309	71,309	4,666	234,363	2,980	305,223	2,405	198,884	1,256	93,115
Korea, Republic of	380	13,086	739	42,429	680	76,754	762	61,842	911	61,561
Mexico	587	22,301	1,009	56,063	890	72,432	1,269	103,208	571	44,541
New Zealand	19	535	42	2,479	17	2,189	18	1,599	18	1,433
Pakistan	[2]21	[2]766	1	96	[2]48	[2]6,206	[2]87	[2]6,951	75	6,744
Peru	6	443	--	--	23	3,103	93	7,767	1	100
Philippines	14	312	--	--	17	2,167	67	6,225	23	1,441
Singapore	25	971	15	1,179	--	--	81	5,761	(1)	4
Spain	721	21,452	1,127	58,197	896	89,696	1,709	131,600	1,862	136,093
Sweden	21	4,545	8	2,171	33	5,138	95	11,266	54	6,822
Taiwan	419	14,028	672	39,527	491	44,454	264	24,168	249	22,063
Thailand	85	2,945	139	8,408	34	3,311	37	3,076	18	1,497
Turkey	125	4,571	124	7,212	57	6,323	89	6,645	159	13,461
United Kingdom	25	1,029	142	9,203	117	14,442	78	9,373	507	43,922
Venezuela	284	7,734	76	3,802	183	17,679	72	4,626	20	1,250
Yugoslavia	--	--	--	--	--	--	37	3,258	28	1,909
Other	43	1,145	18	1,600	43	5,749	31	[r]4,993	67	8,728
Total	7,177	233,395	10,874	570,011	8,497	823,720	9,442	762,976	7,877	601,826

[r]Revised.
[1]Less than 1/2 unit.
[2]Includes Bangladesh: 1972, 14,781 short tons ($521,810); 1974, [r]15,853 short tons [r]($1,951,756); 1975, 56,862 short tons ($4,420,254).

Table 12.—U.S. exports of rerolling material (scrap), by country

(Thousand short tons and thousand dollars)

Country	1972		1973		1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	--	--	--	--	--	--	12	1,055	11	930
Canada	2	118	1	34	7	485	5	408	1	196
China, People's Republic of	--	--	7	485	1	85	--	--	--	--
Germany, West	--	--	--	--	--	--	--	--	2	560
Italy	--	--	2	168	--	--	--	--	--	--
Japan	17	789	16	1,209	1	182	--	--	--	--
Korea, Republic of	73	3,491	118	7,014	81	10,504	29	3,189	44	11,098
Mexico	35	1,883	43	2,954	47	5,269	40	4,623	24	2,464
Nigeria	--	--	--	--	--	--	--	--	7	1,177
Pakistan	24	1,047	8	422	4	617	4	402	3	278
Spain	5	319	(1)	7	--	--	17	1,336	7	599
Taiwan	20	951	149	12,712	57	7,712	39	3,478	55	5,435
Thailand	15	654	28	2,641	--	--	13	1,518	76	8,426
Turkey	9	533	4	292	(1)	40	(1)	61	4	541
Venezuela	3	200	3	210	--	--	--	--	--	--
Other	4	228	3	341	1	131	1	196	7	948
Total	207	10,213	382	28,489	199	25,025	160	16,266	241	32,652

[1]Less than 1/2 unit.

Table 13.—U.S. exports of ships, boats, and other vessels for scrapping

(Thousand short tons and thousand dollars)

Country	1972		1973		1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	36	583	2	260	26	1,414	15	406	4	108
Germany, West	--	--	8	257	13	700	([1])	([1])	([1])	1
Japan	5	74	--	--	--	--	--	--	--	--
Korea, Republic of	--	--	9	370	44	5,826	7	237	6	181
Mexico	--	--	1	132	([1])	23	--	--	([1])	2
Netherlands	--	--	([1])	40	--	--	([1])	1	--	--
Spain	146	3,907	22	1,002	93	8,824	10	426	--	--
Taiwan	112	4,445	114	5,994	139	15,539	8	617	40	1,948
Other	--	--	([1])	1	12	814	([1])	55	([1])	40
Total	299	9,009	156	8,056	327	33,140	40	1,742	50	2,280

[1]Less than 1/2 unit.

Table 14.—U.S. imports for consumption of iron and steel scrap, by country

Country	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	27	$15	285	$19
Bahamas	7,308	200	11,724	472
Belgium-Luxembourg	87	52	92	27
Canada	235,263	18,935	423,240	32,105
Dominican Republic	961	70	16	7
Germany, West	132	71	80	83
Haiti	528	11	346	9
Hong Kong	82	43	--	--
Jamaica	2,197	110	959	35
Japan	56,438	5,233	9,159	437
Leeward and Windward Islands	50	5	--	--
Liberia	--	--	2	1
Mexico	963	158	6,952	459
Netherlands	24	11	14,442	155
Nicaragua	141	25	--	--
Sweden	9	7	38,837	483
Taiwan	378	63	--	--
Trinidad and Tobago	254	9	1	([1])
United Kingdom	397	215	302	704
Other	120	17	728	124
Total	[2]305,359	25,250	[2]507,165	35,120

[1]Less than 1/2 unit.
[2]Includes tinplate.

Table 15.—Iron and steel scrap consumption in selected countries[1]

(Thousand short tons)

	1974	1975	1976
European Economic Community:			
Belgium[2]	5,429	4,091	4,032
Denmark[3]	577	634	854
France[3 4 5]	10,340	8,307	8,964
Germany, West[5]	28,195	22,495	23,263
Ireland	[6]132	[6]100	[e]55
Italy[3]	16,215	[r]15,023	[e]15,400
Luxembourg	2,098	1,513	1,577
Netherlands	2,342	[r]1,748	1,957
United Kingdom[2 5]	18,690	17,526	[7]14,051
Total[8]	[r]84,018	[r]71,437	70,153

See footnotes at end of table.

Table 15.—Iron and steel scrap consumption in selected countries[1] —Continued

(Thousand short tons)

	1974	1975	1976
European Free Trade Association:			
Austria	[5]2,166	r1,881	1,992
Norway[2 4 5]	616	618	593
Portugal	399	[3 5]172	284
Sweden[2 3]	4,119	3,780	e3,640
Total	r7,300	r6,451	6,509
Other European market economy countries:[9]			
Finland	782	767	[3]634
Spain	8,229	[6]7,209	e7,170
Yugoslavia[3 4 5]	1,796	1,883	1,747
Total	r10,807	r9,859	9,551
European centrally planned economy countries:[9]			
Czechoslovakia[2 4 5]	7,626	7,886	8,088
Germany, East[2 3 4 5]	4,836	4,852	5,117
Hungary[2 4 5]	2,288	2,392	2,420
Poland	9,080	e9,370	10,352
Romania[2 4 5 10 e]	3,310	3,530	3,600
U.S.S.R.[2 3 4 5 11]	51,656	51,806	51,900
Total[8]	78,796	79,836	81,477
Latin America:[5 12]			
Argentina	1,953	1,758	e1,930
Brazil	r3,979	4,040	e4,100
Chile	250	185	e190
Colombia	185	248	e175
Mexico	r3,445	3,663	e3,700
Peru	174	192	e110
Venezuela	626	581	e550
Other[13]	r32	44	e40
Total[8]	r10,644	10,711	10,795
Other countries:			
Canada[2 3 4 5]	7,842	7,444	7,131
India[2 3 4 5]	[14]1,680	e1,980	e1,930
Japan[5]	50,867	37,714	42,135
South Africa, Republic of[2 3 4 5 e]	2,690	2,980	3,240
Turkey[2 5]	702	r e660	e800
United States[2]	105,483	82,331	99,109
Total[8]	r169,264	r133,109	154,345
Grand total[8]	r360,829	r311,403	332,830

eEstimate. rRevised.

[1]Unless otherwise noted, figures represent consumption of scrap in the production of pig iron, ferroalloys, crude steel, foundry products and rerolled steel, as well as in other unspecified uses by the steel industry, and by other (unspecified) industries. Also, unless otherwise noted, figures are from: United Nations Economic Commission for Europe, Annual Bulletin of Steel Statistics for Europe. V. IV, 1976. New York, 1977, p. 97.

[2]Excludes scrap consumed in rerolling.

[3]Excludes scrap consumed in foundries.

[4]Excludes scrap consumed within the steel industry for purposes other than the manufacture of pig iron, ferroalloys, crude steel, and foundry products and that used in rerolling.

[5]Excludes scrap used outside the steel industry.

[6]Source: Organization for Economic Cooperation and Development, The Iron and Steel Industry in 1975. Paris, 1976, pp. 66

[7]British Steel Corporation, International Steel Statistics, the United Kingdom, 1976, 43 pp.

[8]Total of listed figures.

[9]Following United Nations practice, Yugoslavia has been included with other market economy countries of Western Europe.

[10]Excludes scrap used in production of pig iron.

[11]Excludes scrap used in production of steel by any method of production except open hearth furnace.

[12]Data for 1974-1975 from Latin American Iron and Steel Institute. Statistical Yearbook of Steelmaking and Iron Ore Mining in Latin America, 1975. Santiago, Chile, 1976, 193 pp. Figures for 1976 are U.S. Bureau of Mines estimates.

[13]Includes Uruguay plus other unspecified countries in Central America, as reported in source.

[14]British Steel Corporation. International Steel Statistics, India, 1974, 57 pp.

Table 16.—Iron and steel scrap exports by selected countries[1]

(Thousand short tons)

	1974	1975	1976
European Economic Community:			
Belgium-Luxembourg	800	586	581
Denmark	143	100	128
France	4,107	3,097	3,772
Germany, West	2,806	[r]2,432	2,863
Ireland	13	9	9
Italy	12	6	26
Netherlands	1,293	1,032	1,055
United Kingdom	343	1,010	660
Total[2]	9,517	8,272	9,094
European Free Trade Association:			
Austria	13	57	50
Norway	37	21	20
Portugal	2	2	6
Sweden	12	12	10
Switzerland	129	129	77
Total[2]	193	221	163
Other European market economy countries:[3]			
Finland	10	6	4
Greece	(4)	(4)	--
Iceland	10	3	4
Spain	2	1	[5 6]--
Yugoslavia	26	24	22
Total[2]	[r]48	34	30
European centrally planned economy countries:[3]			
Bulgaria	118	134	149
Czechoslovakia	265	243	[e]275
Germany, East	29	1	--
Hungary	130	34	41
Poland	496	313	101
U.S.S.R	1,615	1,256	[e]1,320
Total[2]	[r]2,653	1,981	1,886
Latin America:			
Mexico	--	NA	NA
Other[e]	13	10	6
Total[2]	13	10	6
Other countries:			
Australia	974	637	696
Canada	292	463	1,117
India	[7]115	[6]139	[8]116
Japan	332	105	224
Korea, Republic of[6]	1	(5)	21
Morocco[6]	88	(4)	--
New Zealand	[6]2	[e]2	[8]1
Singapore	[6]2	[6]2	[e]2
South Africa, Republic of	NA	NA	NA
Taiwan[6]	52	39	69
Turkey	[5 6]--	--	NA
United States	[r]9,586	[r]10,584	8,949
Total[2]	[r]11,444	[r]11,971	11,195
Grand total[2]	[r]23,868	[r]22,489	22,374

[e]Estimate. [r]Revised. NA Not available.

[1]Unless otherwise noted, source is: United Nations Economic Commission for Europe, Annual Bulletin of Steel Statistics for Europe, V. IV, 1976, New York, 1977, pp. 97.

[2]Total of listed figures.

[3]Following United Nations practice, Yugoslavia has been included with other market economy countries of western Europe.

[4]Revised to none.

[5]Less than 1/2 unit.

[6]Official trade returns of subject country.

[7]Statistiches Bundesamt. Eisen und Stahl, 2d quarter, 1977. Dusseldorf, 1977, 143 pp.

[8]Partial figure; compiled from export statistics of trading partner countries.

Table 17.—Iron and steel scrap imports by selected countries[1]

(Thousand short tons)

	1974	1975	1976
European Economic Community:			
Belgium-Luxembourg	958	779	646
Denmark	4	3	8
France	362	305	302
Germany, West	1,996	[r]1,896	1,703
Ireland	28	4	1
Italy	6,917	5,967	6,914
Netherlands	96	176	177
United Kingdom	154	97	765
Total[2]	10,515	[r]9,227	10,516
European Free Trade Association:			
Austria	97	[r]37	50
Norway	56	60	78
Portugal	9	7	32
Sweden	406	373	151
Switzerland	121	107	49
Total	689	[r]584	360
Other European market economy countries:[3]			
Finland	93	105	60
Greece	26	108	88
Spain	2,122	2,399	[4]2,929
Yugoslavia	461	381	377
Total	2,702	[r]2,993	3,454
European centrally planned economy countries:[3]			
Czechoslovakia[5]	13	34	34
Germany, East	437	384	596
Hungary	2	1	10
Poland	3	2	52
Total[2]	455	[r]421	692
Latin America:			
Argentina	[4] [r]163	[4]352	[5]88
Brazil	[4]6	[4]20	[e]22
Chile	[4]12	[e]10	[5]14
Cuba	[5]65	[5]61	[e]66
Mexico	[4]874	[e]1,400	[5]595
Peru	--	NA	[5]1
Venezuela	[4]182	[4]62	[5]20
Other[e]	4	3	3
Total[2]	[r]1,306	[r]1,908	809
Other countries:			
Canada	848	1,024	907
China, People's Republic of[5]	188	219	52
Egypt	NA	NA	[5]41
India	[4]11	[4]22	[e]13
Iran	[4]7	[4]8	[e]11
Japan	3,923	3,409	1,986
Korea, Republic of[4]	1,235	930	1,206
Philippines	[4]19	[5]67	[5]23
Singapore	[4]29	[4]106	[e]110
South Africa, Republic of[4]	10	20	37
Taiwan[4]	866	389	327
Thailand[4]	282	294	304
Turkey	[4]130	94	[5]163
United States	201	305	507
Total[2]	[r]7,749	6,887	5,687
Grand total[2]	[r]23,416	22,020	21,518

[e]Estimate. [r]Revised. NA Not available.
[1]Unless otherwise noted, source is: United Nations Economic Commission for Europe, Annual Bulletin of Steel Statistics for Europe, V. IV, 1976, New York, 1977, pp. 97. It should be noted that among major steel producing nations, the U.S.S.R. and Romania do not import any substantial quantity of scrap.
[2]Total of listed figures.
[3]Following United Nations practice, Yugoslavia has been included with other market economy countries of western Europe.
[4]Official trade returns of subject country.
[5]Partial figure; compiled from export statistics of trading partner countries.

Kyanite and Related Materials

By Michael J. Potter[1]

Kyanite, andalusite, and sillimanite are anhydrous aluminum silicate minerals that are alike in both composition and use patterns and have the same chemical formula, $Al_2O_3 \cdot SiO_2$. Related materials include synthetic mullite, dumortierite, and topaz, also classified as aluminum silicates, although the last two additionally contain substantial proportions of boron and fluorine, respectively. All of these kyanite-group substances have the capability of serving as raw materials for manufacturing special high-performance refractories in the high-alumina category, but there has been no record in recent years of significant utilization of either dumortierite or topaz for this purpose in the United States.

Although published statistics are not sufficiently complete to be wholly conclusive, it appears that the United States, India, and the Republic of South Africa are the leading world producers of kyanite-group minerals. It can be presumed that the U.S.S.R. and perhaps a few other industrialized nations also produce significant quantities of these materials.

U.S. kyanite production in 1976 was slightly higher in tonnage and value than in 1975. During 1976 the expanded processing facilities of C-E Minerals, Inc., were successfully debugged. Partly because of sluggish sales, completion of Kyanite Mining Corp.'s third plant is now scheduled for 1977.[2]

Legislation and Government Programs.—The allowable depletion rates for kyanite, established by the Tax Reform Act of 1969 and unchanged through 1976, were 22% for domestic production and 14% for foreign operations.

DOMESTIC PRODUCTION

Kyanite was produced in the United States in 1976 at three open pit mines: Two in Virginia and one in Georgia. Kyanite Mining Corp. operated the Willis Mountain mine in Buckingham County, Va., and the Baker Mountain mine in adjoining Prince Edward County, Va. C-E Minerals, Inc., operated the Graves Mountain mine in Lincoln County, Ga.

Domestic kyanite output in 1976 was slightly higher in tonnage and value than in 1975. Specific kyanite production statistics for 1976 (as well as for all previous years since 1949) are withheld to avoid disclosure of individual company confidential data.

Synthetic mullite production showed a substantial increase in both tonnage and value compared with 1975 and output was largely of the high-temperature sintered variety. The four producers of this material were A. P. Green Refractories Co. at Philadelphia, Pa.; C-E Minerals, Inc. at Americus, Ga.; Harbison-Walker Refractories Co. at Eufala, Ala.; and Taylor Refractories Division, NL Industries, Inc., at Greenup, Ky. Electric-furnace-fused mullite was produced by The Carborundum Co. at Niagara Falls, N.Y.

[1]Physical scientist, Division of Nonmetallic Minerals.
[2]Radcliffe, D. Industrial Minerals-Kyanite. Min. Eng., v. 29, No. 3, March 1977, p. 64.

Table 1.—Synthetic mullite production in the United States

Year	Quantity (short tons)	Value (thousands)
1972	46,389	$4,080
1973	58,176	5,211
1974[r]	41,508	5,895
1975	24,147	3,350
1976	42,228	5,453

[r]Revised.

CONSUMPTION AND USES

Kyanite and related materials, conforming to established end use patterns, were consumed in 1976 mostly in the manufacture of high-alumina or mullite-class refractories and in lesser quantities as ingredients in some ceramic compositions. Domestic kyanite, already ground to minus 35-mesh as required by the flotation process used in its separation and recovery, was marketed in the raw form or after heat treatment; that is, as mullite, which was sometimes further reduced in particle size before use. In the 35- to 48-mesh range, the mineral was used mostly in monolithic refractory applications such as for high-temperature mortars or cements, ramming mixes, and castable refractories, or with clays and other ingredients in refractory compositions for making kiln furniture, insulating brick, firebrick, and a wide variety of other articles. More finely ground material, minus 200-mesh for example, was used in body mixes for sanitary porcelains, wall tile, precision casting molds, and miscellaneous special-purpose ceramics.

PRICES

Engineering and Mining Journal, December 1976, listed prices for kyanite, f.o.b. Georgia, ranging from $63 to $118 per short ton for bulk shipments and $9 more per ton for bagged material.

Price ranges quoted for kyanite-group materials in Ceramic Industry Magazine, January 1977 follow:

	Per short ton
Andalusite	$30-$60
Kyanite	63-125
Mullite, calcined	302-313
Mullite, fused	160-450

The December 1976 issue of Industrial Minerals (London) quoted kyanite-group price ranges approximately equivalent (with some uncertainty due to a floating exchange rate) to the following:

	Per short ton
Andalusite, Transvaal, c.i.f. main European port	$100
Kyanite, Indian, f.o.b.	93
Sillimanite, Indian, natural bagged, f.o.b.	[1]57
Kyanite, Indian, calcined, f.o.b. Calcutta	136-$143

[1]Nominal.

FOREIGN TRADE

The amount of kyanite-group material exported in 1976 showed a substantial decrease compared with 1975. It can be supposed that the greater part of material currently being exported by the U.S. consists of mullite. It should be noted, however, that some element of uncertainty is inherent in such conclusions because Bureau of the Census export figures, on which they are based, do not clearly distinguish synthetic mullite from some other mullite-containing materials prepared by high-temperature processing of certain bauxitic and kaolinitic minerals.

The tonnage of imported material continued to be small, although it showed an increase over that of 1975. For the first time, India did not appear as an exporter to the United States.

Table 2.—U.S. exports and imports for consumption of kyanite and related minerals

	1974		1975		1976	
	Quantity (short tons)	Value	Quantity (short tons)	Value	Quantity (short tons)	Value
Exports:						
Argentina	110	$14,028	160	$14,926	325	$22,686
Australia	12,578	656,843	9,918	615,663	14,886	1,087,338
Belgium-Luxembourg	1,305	97,557	221	58,062	1,049	94,541
Brazil	2,465	217,703	582	29,700	309	32,788
Canada	6,843	468,929	5,175	361,361	4,857	362,709
Colombia	210	14,656	301	20,869	58	2,934
Denmark	--	--	134	11,919	--	--
France	286	57,057	600	69,973	300	45,234
Germany, West	54,090	2,908,878	65,487	3,582,084	14,181	1,011,056
Guatemala	125	8,428	--	--	--	--
Hong Kong	5	809	48	7,262	--	--
Israel	--	--	200	11,255	--	--
Italy	12,085	970,953	13,066	921,974	6,907	600,611
Japan	16,483	988,077	30,666	1,796,826	5,406	428,012
Mexico	4,776	366,032	3,045	318,374	4,130	391,763
Netherlands	12,159	606,341	1,120	84,598	131	11,057
New Zealand	40	3,519	20	1,690	21	1,851
Philippines	151	17,726	12	2,205	219	24,874
South Africa, Republic of	32	5,573	3	1,168	2	1,126
Spain	4,289	202,804	--	--	21	1,735
Sweden	5,365	335,787	5,755	385,925	3,028	261,251
Switzerland	84	6,851	--	--	--	--
Taiwan	66	1,896	49	3,542	--	--
U.S.S.R	--	--	1,734	170,182	--	--
United Kingdom	1,746	185,058	11,110	739,346	6,940	509,519
Venezuela	622	65,183	850	137,230	481	45,904
Other	67	4,286	113	9,277	78	4,699
Total	135,982	8,204,974	150,369	9,355,411	63,329	4,941,688
Imports:						
India	110	4,939	65	2,849	--	--
Mexico	17	2,005	--	--	65	7,225
Netherlands	11	620	--	--	--	--
South Africa, Republic of	56	4,848	--	--	45	5,172
Total	194	12,412	65	2,849	110	12,397

WORLD REVIEW

France.—Imports of kyanite-group minerals amounted to 7,860 tons in 1974. The principal countries of origin and the percent supplied were India, 34%; the United States, 31%; and Belgium-Luxembourg, 15%. In 1975, kyanite-group imports totaled 6,000 tons. Principal countries of origin and share supplied were India, 32%; the United States, 22%, and Belgium-Luxembourg, 13%.[3]

Although the Republic of South Africa is the principal producer of andalusite, France is now said to be in second place with production of "Kerphalite," a type of andalusite mined near Kerphales in Brittany. A publication described the operation and extraction (at Glomel) and the properties and refractory applications of the products.[4]

Germany, West.—Imports of kyanite-group minerals in 1975 amounted to 26,100 tons. Principal countries of origin and the share supplied were the Republic of South Africa, 27%; India, 25%; and the United Kingdom, 14%.[5]

India.—A report entitled "Kyanite and Sillimanite, a Market Survey" was released by the Mineral Economics Division of the Indian Bureau of Mines. The report includes an estimate of kyanite and sillimanite demand in India and elsewhere over the next 10 years. Also included are sections on uses and specifications, supply, trade, and prices.[6]

The Geological Sur'ey of India planned to investigate reserves at sillimanite deposits

[3]Industrial Minerals (London). French Industrial Mineral Imports 1975. No. 109, October 1976, p. 51.
[4]Industrial Minerals (London). "Kerphalite" Europe's Own Source of High-Alumina Andalusite for Refractories. No. 104, May 1976, p. 27.
[5]Industrial Minerals (London). West German 1974-75 Industrial Mineral Imports. No. 105, June 1976, p. 43.
[6]Industrial Minerals (London). Publications. No. 108, September 1976, p. 56. Report is available from Regional Controller of Mines, Plot No. 95, Bungalow No. 267, East High Court Road, New Ramdaspeth, Nagpur 440010, India.

in Meghalaya. Mines at these deposits were leased by Assam Sillimanite Ltd. (ASL) until 1973, with some 143,000 tons of sillimanite being mined since 1950. Hindustan Steel Ltd. took over the mines from ASL.[7]

Japan.—Imports of kyanite-group minerals amounted to 31,785 tons in 1974. The principal countries of origin and the percentage supplied were the Republic of South Africa, 65%; India, 25%; and the United States, 10%. In 1975 kyanite-group imports were 25,950 tons. Principal countries of origin and percent supplied were the Republic of South Africa, 58%; India, 31%; and the United States, 10%.[8]

Nigeria.—The Nigerian Government was to invest $760 million in exploiting mineral and water resources during the current plan period. Of this amount, $5.3 million was to be spent on development of known deposits of several nonmetallic minerals, including kyanite.[9]

United Kingdom.—For the first 6 months of 1975, imports of kyanite-group minerals amounted to 18,800 tons. Principal countries of origin and the share supplied were the Republic of South Africa, 64%; France, 14%; the United States, 12%; and India, 5%. Imports of kyanite-group minerals for the first half of 1976 were 18,535 tons. The principal countries of origin and percentage supplied were the Republic of South Africa, 65%; France, 24%; India, 5%; and the United States, 5%.[10]

[7]Industrial Minerals (London). Company News & Mineral Notes. No. 105, June 1976, p. 45.
[8]Industrial Minerals (London). Japanese Industrial Mineral Imports. No. 108, September 1976, p. 51.
[9]Industrial Minerals (London). Company News & Mineral Notes. No. 101, February 1976, p. 50.
[10]Industrial Minerals (London). UK Mineral Imports, January-June 1976. No. 108, September 1976, p. 50.

Table 3.—Kyanite, sillimanite and related materials: World production, by country[1]

(Short tons)

Country and commodity[2]	1974	1975	1976[p]
Australia: Sillimanite[3]	828	[e]835	[e]700
France: Kyanite and andalusite	10,860	[e]11,000	[e]11,000
India:			
Kyanite	[r]49,975	55,447	49,945
Sillimanite	[r]3,252	8,946	16,083
Korea, Republic of: Andalusite	127	117	573
South Africa, Republic of:			
Andalusite	70,557	85,042	85,389
Sillimanite	14,426	18,641	28,366
Spain: Andalusite	8,059	5,558	[e]6,600
United States:			
Kyanite	W	W	W
Synthetic mullite	41,508	24,147	42,228

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]Owing to incomplete reporting, the table has not been totaled.
[2]In addition to the countries listed, a number of other countries presumably produced kyanite and related minerals, but output data are not reported and no basis is available for estimates of output levels.
[3]In addition, sillimanite clay (also called kaolinized sillimanite) is produced, but available information is inadequate to make reliable estimates.

TECHNOLOGY

A patent was granted for making aluminum powder from kyanite. The procedure includes mixing beneficiated kyanite and powdered coal to make briquets or pellets, reducing the agglomerates in an electric furnace, grinding and hydroaluminating the aluminum-silicon alloy, and pyrolyzing or decomposing the resultant material in an oil medium to form aluminum powder.[11]

In its annual review of materials for ceramic processing, an industrial journal presented brief studies of the kyanite-group minerals and their contributions to modern technology.[12]

The Federal Bureau of Mines ran some acid leaching studies on a high-iron kyanite concentrate produced from a North Carolina weathered surface ore. Results indicated that specification-grade kyanite concentrates could be produced from this material by leaching with acid to react with the contained iron. In other Bureau work, in cooperation with the U.S. Forest Service, kyanite and garnet analyses were run on some samples from Idaho. The analytical treatment involved scrubbing, acid leaching, heavy-liquid separation, and magnetic separation.

A patent was granted for the fabrication of structural bodies from mullite powder.[13]

A journal article described the occurrence, characteristics, and purification of Korean andalusite. The ore, which contained mainly andalusite, muscovite, biotite, and small amounts of other minerals, was studied by optical microscopy, X-ray diffraction, and other methods. After hand cobbing, stage crushing of the ore increased the distribution of andalusite in coarse particles and that of mica in fine particles.[14]

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[11]Gautreaux, M. F., J. H. McCarthy, W. E. Foster, D. O. Hutchinson, and F. W. Frey (assigned to Ethyl Corp.). Production of Aluminum From Kyanite. U.S. Pat. 3,860,415, Jan. 14, 1976.

[12]Ceramic Industry. Andalusite. V. 108, No. 1, January 1977, p. 44.

———. Dumortierite. V. 108, No. 1, January 1977, p. 64.

———. Kyanite. V. 108, No. 1, January 1977, p. 75.

———. Mullite. V. 108, No. 1, January 1977, p. 86.

———. Sillimanite. V. 108, No. 1, January 1977, p. 99.

———. Topaz. V. 108, No. 1, January 1977, p. 109.

[13]Mazdiyasni, K. S., and L. M. Brown (assigned to the U.S. Secretary of the Air Force). Mullite Powder and Fabrication of Structural Bodies Therefrom. U.S. Pat. 3,922,333, Nov. 25, 1975.

[14]Ahn, Y. P., and L. Choi. Use of Yun Chun Andalusite As a Raw Material of High-aluminia Refractories: I, Occurrence and General Characteristics; II, Concentration and Purification. J. Korean Ceram. Soc., v. 11, No. 1, 1974, pp. 19-28.

Lead

By J. Patrick Ryan,[1] John M. Hague,[1] and John A. Rathjen[2]

In 1976 world mine production of lead at 3.7 million tons represented a slight decline from the 1975 level. Smelter production, however, recovered from the low level of 3.66 million tons in 1975, rising to 3.79 million tons in 1976. World metal consumption was estimated to be about 4.7 million tons, including use of refined secondary metal, a 9% increase above consumption in 1975. The increase came in part from increased secondary production and in part from drawdown of stocks. World producers' stocks outside planned economy countries decreased from 298,000 tons at the beginning of the year to 223,000 tons at yearend.

The U.S. producer price of lead increased in several steps throughout the year from 19 cents per pound in January to a split price of 25.5 to 26 cents at yearend. The London Metal Exchange (LME) price ranged from an average of 15.2 cents per pound in January in terms of U.S. currency to 23.1 cents in July and then retreated through the succeeding months, ending the year at 21.7 cents. During the first half of the year the LME price was only 1 or 2 cents below the U.S. price but during the second half the spread became 3 to 5 cents per pound.

Domestic mine production decreased 2% from the 1975 level to 609,500 tons in 1976. Primary refinery production from domestic and foreign concentrates on the other hand increased 3% over that of 1975 to 657,519 tons in 1976, despite a strike at one smelter. Secondary smelter production increased 10% to a record level of 726,600 tons, more than half of the total lead production.

Consumption of lead in the United States recovered from the depressed level of 1975, increasing 15% to 1.49 million tons in 1976. The increase in demand was caused by the need for original equipment batteries in a greater number of new cars and by sales of more replacement batteries toward the end of the year as severe winter weather increased battery replacements. Lead requirements for battery manufacture used 55% of the total supply; gasoline antiknock compounds, 16%; pigments, 7%; ammunition, 5%; and other uses, 17%.

Stocks of refined and antimonial lead at primary smelters decreased from 81,300 tons at the beginning of the year to 43,700 tons at yearend, and consumers' stocks of soft lead and lead in antimonial lead and other alloys changed from 131,700 tons on January 1 to 127,900 tons on December 31, resulting in a substantial reduction of 41,400 tons in combined stocks.

Legislation and Government Programs.—The General Services Administration (GSA) reported net sales of lead from the Government stockpile totaled 459 tons in 1976. The total uncommitted inventory at yearend was 601,160 tons, as primary producers stocks remained above the 52,584-ton trigger point for GSA lead released through September 1976.

GSA announced on October 1 that the stockpile goal for lead had been raised from 65,100 tons to 865,000 tons and that the Government was canceling its obligation to deliver any lead remaining to be delivered under contracts with producers.

Public Law 94-413, known as the Hybrid Vehicle Research, Development, and Demonstration Act of 1976, was enacted on September 17, 1976. The law authorized a $160 million Federal program to foster development and demonstrate over a 5-year period (1977-81), the commercial feasibility of electric vehicles. The program, to be carried out by the Energy Research and Development Administration (ERDA), provided for production of 7,500 cars for demonstration by Government agencies and the public. Because a substantial part of the authorized funds were to be allocated for battery research, including the lead-acid

[1]Physical scientist, Division of Nonferrous Metals.
[2]Mineral specialist, Division of Nonferrous Metals.

battery, the program could have a major impact on the battery manufacturing industry and the future demand for lead.

On June 23, 1976, the Lead-Based Paint Poisoning Prevention Act was extended and revised by enactment of the National Consumer Health Information and Health Promotion Act of 1976, (Public Law 94-317). The Act directs Federal agencies to take action with respect to determining a safe level of lead in paint. Public hearings were held on September 13, 1976.

On petition by interested parties requesting revocation of its earlier dumping findings on imports of lead metal from Australia and Canada, the International Trade Commission, on review of the evidence and factual data, determined that if the findings were revoked, an industry in the United States would not likely be injured by importation of such primary lead metal at less than fair market value.

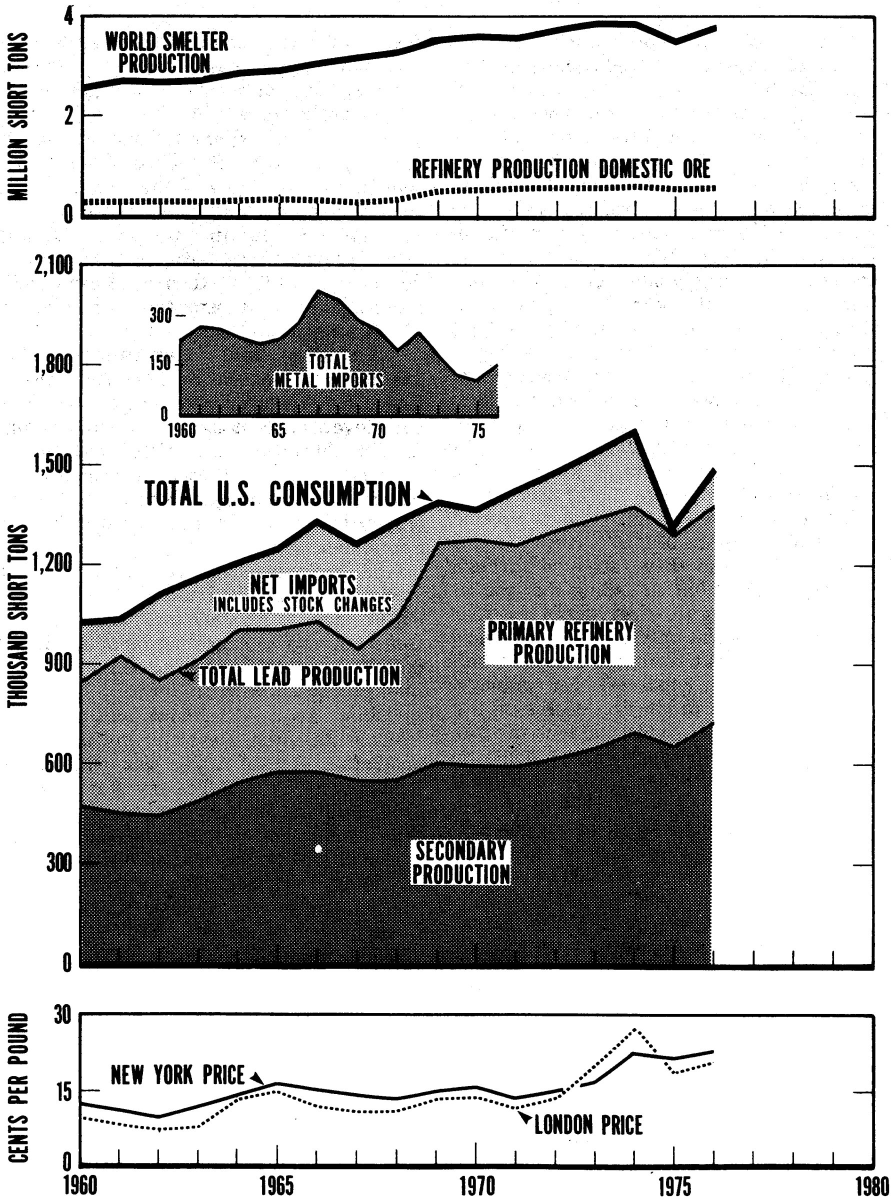

Figure 1.—Trends in the lead industry in the United States.

Table 1.—Salient lead statistics
(Short tons unless otherwise specified)

	1972	1973	1974	1975	1976
United States:					
Production:					
Domestic ores, recoverable lead content	618,915	603,024	663,870	621,464	609,546
Value ... thousands	$186,046	$196,465	$298,742	$267,230	$281,613
Primary lead (refined):					
From domestic ores and base bullion	577,398	567,256	580,078	530,215	568,536
From foreign ores and base bullion	103,001	107,260	92,946	105,907	84,341
Antimonial lead (primary lead content)	8,185	13,223	9,867	2,125	4,642
Secondary lead (lead content)	616,597	654,286	698,698	658,456	726,569
Exports of lead materials, excluding scrap	8,376	66,576	61,982	21,256	5,877
Imports, general:					
Lead in ore and matte	101,282	109,947	94,299	87,560	76,365
Lead in base bullion	895	4	831	462	2,334
Lead in pigs, bars, and old	245,853	181,486	119,579	105,876	150,345
Stocks December 31 (lead content):					
At primary smelters and refineries	145,573	89,847	121,051	156,530	104,543
At consumer plants and secondary smelters	118,544	124,121	166,589	133,315	129,610
Consumption of metal, primary and secondary	1,485,254	1,541,209	1,599,427	1,297,098	1,490,072
Price: Common lead, average, cents per pound[1]	15.03	16.29	22.53	21.53	23.10
World:					
Production:					
Mine	3,801,094	3,843,723	r3,762,489	r3,750,210	3,700,742
Smelter	3,723,409	3,837,864	r3,828,701	r3,656,145	3,788,134
Price: London, common lead, average, cents per pound	13.68	19.47	26.83	18.73	20.46

rRevised.
[1]Quotation on nationwide, delivered basis.

The International Lead and Zinc Study Group (ILZSG) held its 20th session in Geneva, Switzerland, November 8-12 to review the situation in lead and zinc and the outlook for 1977, and long-term lead and zinc trends. ILZSG provided estimates of world production and consumption of lead and zinc that reflected a strong recovery in world economic activity from the low levels of 1975. ILZSG estimates for 1976 and forecasts for 1977 showed lead supply and demand in close balance with little change in stock levels. A review of new mine and smelter projects disclosed several new zinc-lead mines under development and scheduled for production in 1977 and 1978, including Tara in Ireland and Rubiales in Spain. Several new and expansion smelter projects, both primary and secondary, also were scheduled for startup in 1977 and 1978.

DOMESTIC PRODUCTION

MINE PRODUCTION

Output of lead from U.S. mines in 1976 totaled 609,500 tons, about 2% less than in 1975. Monthly production reached a maximum in March of 57,800 tons, about 1% less than the maximum achieved in the same month in 1975. Production from Missouri mines decreased 3% to 501,000 tons and accounted for 82% of the Nation's total output of lead. Production in Idaho, which provided 9% of the total, was 6% more than in 1975 reflecting increased output at the Lucky Friday and Star mines. Colorado's production was down 1% but mine output in Utah continued to rise for the second consecutive year in 1976 after reaching a 70-year low in 1974. The 29% gain in Utah's output was attributed to increased production from the Ontario mine near Park City which more than offset lower production from the Burgin mine.

The Buick mine, jointly owned by AMAX Lead Co. of Missouri and Homestake Lead Co., was the Nation's leading lead producer for the sixth consecutive year although output of ore, concentrates, and contained lead declined moderately from the record levels achieved in 1975. Ore milled in 1976 totaled 1.61 million tons averaging 9.9% lead and 3.9% zinc from which 204,574 tons of lead concentrate and 94,734 tons of zinc concentrate were produced. Ore reserves decreased 0.78 million tons to about 28 million tons at yearend. Average grade of reserves was 7.0% lead and 2.0% zinc.[3]

The seven leading mines, all in Missouri, provided 78% of the total U.S. mine production of lead compared with 79% in 1975. The 12 leading mines produced 91% and the 25 leading mines accounted for 99% of the total, the same as in 1975. About 4,700 persons were employed at the Nation's lead

[3]Homestake Mining Co. 1976 Annual Report. P. 17.

lead-silver, and lead-zinc mines and mills in 1976. Output of lead and zinc from these mines was approximately 165 tons per man-year. Average grade of lead ore mined was 5.89% lead and 0.97% zinc, compared with 6.17% lead and 0.89% zinc in 1975.

St. Joe Minerals Corp., the Nation's largest lead-mining and smelting company, operated its four underground mine-mill units in the New Lead Belt of southeast Missouri at full capacity during the year. The four units, Fletcher, Brushy Creek, Viburnum, and Indian Creek, accounted for approximately one-third of the total U.S. mine production in 1976. The company reported that concentrate production was 316,570 tons containing 221,404 tons of lead, compared with 284,200 tons of concentrate and 201,434 tons of lead produced in 1975. St. Joe mines also produced 17,936 tons of zinc in concentrates and 3,169 tons of copper in concentrates. Tons produced per man-shift worked underground ranged from a low of 30 tons to a high of 55 tons.[4]

In Idaho, Hecla Mining Co. reported that its Lucky Friday mine produced 186,520 tons of ore assaying 14.41 ounces of silver per ton, 10.91% lead, and 1.47% zinc in 1976, compared with 173,245 tons assaying 14.96 ounces of silver per ton, 10.71% lead, and 1.29% zinc in 1975. About 20,100 tons of lead, 2.64 million ounces of silver, and 2,600 tons of zinc were contained in the concentrates produced. Ore reserves at yearend at Lucky Friday totaled 475,000 tons compared with 505,000 tons at yearend 1975. Hecla also reported that mine production at the Star-Morning mine, jointly owned by Hecla (30%) and The Bunker Hill Co. (70%), totaled 282,037 tons of ore, slightly less than in 1975. Hecla's share of the 1976 production was 84,612 tons of ore assaying 2.98 ounces of silver per ton, 5.61% lead, and 6.05% zinc. Hecla's 30% share of the computed ore reserves was 344,000 tons, about 50,000 tons less than at yearend 1975.[5]

The Bunker Hill Co. (a subsidiary of Gulf Resources and Chemical Corp.) reported production from company-owned mines aggregated 35,000 tons of lead, about 2,000 tons more than in 1975. Ore production at The Bunker Hill mine increased approximately 10% to a record level. At the Pend Oreille mine ore production increased about 25%. The company also reported that proven and probable ore reserves at yearend 1976 in the Bunker Hill mine totaled 3.09 million tons averaging 2.2% lead, 3.4% zinc, and 1.4 ounces of silver per ton. In addition, the company's 70% interest in proven and probable ore at the Star mine totaled 703,000 tons averaging 6.9% lead, 8.0% zinc, and 4.0 ounces of silver per ton.[6]

In Colorado, Idarado Mining Co. mined and milled 361,000 tons of ore averaging 2.40% lead, 3.83% zinc, and 0.49% copper, compared with 406,000 tons of ore averaging 2.28% lead, 3.24% zinc, and 0.63% copper treated in 1975. Ore reserves at yearend were 3.48 million tons, about 5% less than at yearend 1975. The company reported an 11% reduction in ore milled, reduced development activity, and increased mine productivity which lowered mine operating costs and partly offset sharply higher smelter treatment charges. At the Leadville mine, also known as the Resurrection mine, a joint venture of ASARCO Inc. and Newmont Mining Corp., 200,000 tons of lead-zinc-silver ore was treated, slightly less than in 1975. The average grade of ore milled in 1976 was 4.25% lead, 9.26% zinc, and 2.2 ounces of silver per ton compared with 4.23% lead, 8.68% zinc, and 2.2 ounces of silver per ton in 1975.[7] Lead metal production was about 7,300 tons, 200 tons less than in 1975.[8] Ore reserves at yearend 1976 were estimated at 1.96 million tons averaging 4.96% lead, 9.94% zinc, 2.71 ounces of silver and 0.08 ounce of gold per ton, down from 2.27 million tons at the end of 1975.

SMELTER AND REFINERY PRODUCTION

Output of primary refined lead and lead in antimonial lead from the Nation's five primary refineries in 1976 totaled 657,519 tons, about 3% more than in 1975. About 87% of the total output was recovered from domestic ores. Antimonial lead production at primary refineries increased about 12% to 6,743 tons. The average antimony content of the alloy increased from 9.4% to 10.8%.

St. Joe's smelter-refinery at Herculaneum, Mo., the largest in the United States, operated at close to capacity in 1976. Production of lead and lead alloys totaled 222,483 tons, 20% more than in 1975 reflecting strong demand for lead throughout the year particularly from the battery industry and manufacturers of lead alkyls for gasoline.[9]

[4]St. Joe Minerals Corp. 1976 Annual Report. P. 8.
[5]Hecla Mining Co. 1976 Annual Report. P. 6.
[6]Gulf Resources and Chemical Corp. 1976 Annual Report. Pp. 11-12.
[7]Newmont Mining Corp. 1976 Annual Report. Pp. 5-6.
[8]ASARCO Inc. 1976 Annual Report. P. 18.
[9]Page 8 of work cited in footnote 4.

ASARCO reported that its Omaha, Nebr., and Glover, Mo., refineries produced 197,300 tons of lead, slightly less than in 1975. The company began work at midyear on a comprehensive modernization and air-quality control program designed to bring its copper and lead smelters at El Paso, Tex., into compliance with government standards. The new facilities will include a totally enclosed ore handling system to minimize air pollution from incoming copper and lead ores, a new lead sintering plant, and an 800-ton-per-day sulfuric acid plant to control sulfur dioxide emissions from the copper concentrate roasters and the lead concentrate sinter machine. Construction of these facilities was to begin in 1977 and the entire $98 million modernization program is scheduled for completion in 1978. At the company's East Helena, Mont., lead smelter a $37 million modernization program, underway in 1976, included a 500-ton-per-day acid plant and extension of the updraft sinter machine. Completion of the project was scheduled for the third quarter of 1977. Base bullion produced at the El Paso and East Helena custom smelters was treated at the Omaha refinery. The Glover smelter-refinery, which treated concentrates from the Ozark mine at Sweetwater, Mo., was closed by a strike extending through the last 4 months of the year resulting in a loss of 32,000 tons of refined lead production.[10]

The East Helena smelter processed ores and concentrates from about 115 domestic mines in 10 States and from mines in Australia, Canada, Colombia, Honduras, and Peru. The El Paso smelter processed ores and concentrates from approximately 28 domestic mines in 5 States and from mines in Canada, Honduras, Mexico, Nicaragua, and Peru.

The AMAX-Homestake smelter-refinery at Boss, Mo., processed 196,800 tons of concentrates and produced 134,100 tons of refined lead, slightly less than in 1975. Approximately one-half of the production of refined lead at the smelter was tolled for others.[11]

The Bunker Hill smelter-refinery of Gulf Resources and Chemical Corp. produced 108,000 tons of lead in all forms, about 12% less than in 1975. The company reported that the falloff in production in 1976 resulted from curtailment of smelter operations in order to comply with pollution control regulations; however, completion of a tall chimney (stack) in mid-1977 should enable the smelter to operate near capacity. The Bunker Hill smelter processed concentrates from mines in seven States, Canada, Greenland, and Peru.

Secondary smelter production from recycled materials in 1976 increased 10% to a record high level of 726,600 tons of lead, about 52% of the total smelter and refinery production. Approximately 115 secondary plants were engaged in recovering lead and lead alloys from recycled scrap during the year. Secondary metal output represented nearly 49% of the total lead consumption in 1976. Approximately 43% of the total secondary lead production was recovered in the form of lead metal, 47% as antimonial lead, and the remaining 10% in other lead alloys.

RAW MATERIAL SOURCES

Primary smelters and refineries processed ores and concentrates from domestic mines yielding 570,800 tons of refined lead and antimonial lead, about 87% of the total primary refinery production. Refined and antimonial lead recovered from imported concentrates smelted during the year totaled 86,700 tons, 19,700 tons less than in 1975. Lead recovered from lead scrap processed at primary plants dropped to 1,400 tons, largely contained in antimonial lead.

Scrap materials consumed in 1976 totaled about 1 million tons, 93,800 tons more than in 1975. New scrap in the form of purchased drosses and residues from a variety of sources aggregated 151,000 tons, about 11% more than in 1975 and a record high consumption. New scrap accounted for 15% of the total scrap processed, the same as in 1975. The remainder, old scrap, was largely battery plates, cable lead, soft and hard lead with smaller quantities of type metal, solder, and babbitt. About 4,400 tons of reclaimed scrap was imported from foreign countries for processing in domestic plants.

[10]Pages 9 and 11 of work cited in footnote 8.
[11]Page 17 of work cited in footnote 3.

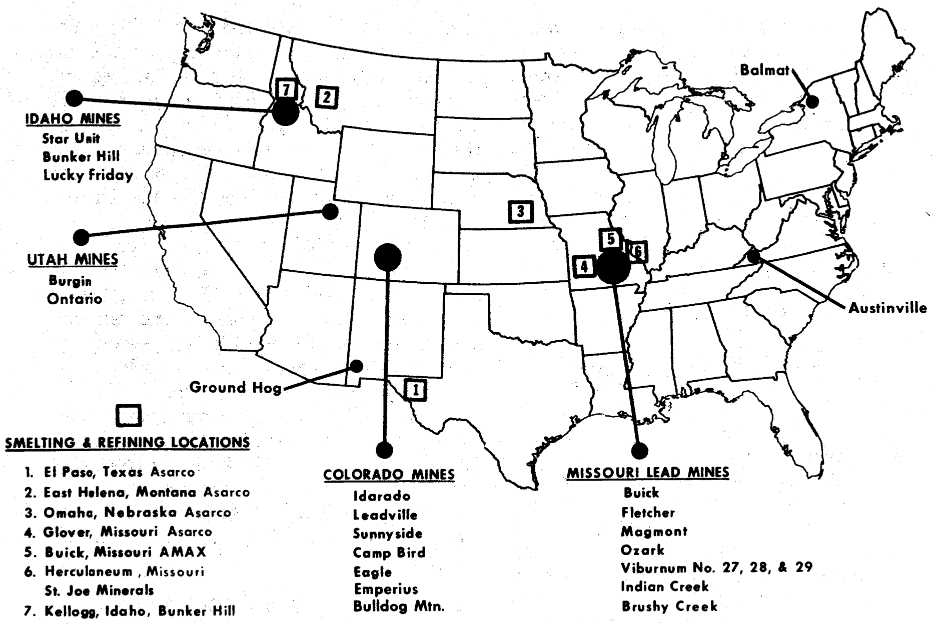

Figure 2.—Lead mines and smelters in the United States.

CONSUMPTION AND USES

Domestic consumption of lead in 1976 totaled 1.49 million tons, 15% above the 8-year low level of consumption established in 1975. On a monthly basis, consumption ranged from a low of 103,400 tons in July to a high of 137,400 tons in October. The use of lead increased in all major product categories. In metal products, battery requirements were up nearly 18%, ammunition was down 2%, but solders increased 10%. Lead used in pigments, principally red lead and litharge was up 33%, and lead used in gasoline antiknock compounds was 15% greater than in 1975. Miscellaneous and other unclassified uses of lead combined increased 30%. According to type of material consumed, soft refined lead represented 67% of the total consumption; antimonial lead accounted for 28%; lead in other alloys accounted for 4%; and lead in copper-base scrap accounted for about 1%.

The 18% gain in lead requirements for battery grids and oxides was attributed to increased demand for original equipment starting, lighting, and ignition (SLI) batteries, reflecting a 28% gain in production of motor vehicles, and to increased requirements for replacement batteries attributed mainly to severe winter weather conditions in many parts of the country. Approximately 62.1 million SLI-type batteries were produced in 1976, 14.9 million more than in 1975. Of the total battery production 48.2 million were replacement and 13.9 million were original equipment, representing gains of 18% in replacement and 114% in original equipment. The 15% gain in the quantity of lead used in antiknock additives in 1976 was attributed essentially to increased gasoline production, increased exports, and buildup of stocks. Lead used in battery manufacture accounted for about 55% of total lead consumption. Lead requirements for antiknock compounds represented 16% of the total; pigments accounted for 7%; ammunition, 5%; miscellaneous and other unclassified uses, 4%; and other metal products, the remaining 13%.

The domestic supply of lead metal from all sources—primary and secondary production, imports for consumption, industry stock changes, and stockpile releases—totaled about 73,700 tons more than reported consumption and exports. The apparent excess supply in 1976 was attributed largely to unreported consumption, incomplete export data, and stock buildup, especially by small producers, consumers, and dealers that do not report to the Bureau of Mines.

LEAD PIGMENTS

Consumption of pig lead for manufacture of lead oxides, pigments, and compounds was 516,768 tons in 1976, an increase of 21,082 tons from the 1975 total. A small decline in use for manufacture of litharge, and white lead was more than offset by increased use for production of black oxide and red lead. The largest increase was in requirements for battery oxide, which rose to 374,761 tons in 1976, an increase of 7% from the 1975 total. Most of the litharge and black oxide produced went to battery manufacturers. Total shipments of litharge in 1976 were 122,462 tons, a gain of 1,987 tons from that reported in 1975. A decline in use for ceramics and rubber was offset by a sharp increase in demand for litharge by the paint industry. Shipments of white lead continued on the down trend with only 1,625 tons of domestic production shipped during the year.

Prices.—The published price for litharge as listed in the Chemical Marketing Reporter was 24 cents per pound in carload lots, ex-works, on January 1. During the week of January 5 the price softened and was quoted in a range of 23.75 to 24.00 cents per pound. The price for litharge remained at this level until mid-May, when it was increased to 24.25 to 26.25 cents per pound. The quotation remained firm until the week of October 11, when a price of 30.25 cents per pound was established which held through the remainder of the year. The quoted price for red lead (Pb_3O_4), 95%, carload lots at plant, followed a similar pattern, rising in several steps from 24 cents per pound in January to 31.25 to 32.5 cents per pound in October, where it remained firm through yearend. Basic carbonate of white lead advanced 6 cents per pound, from 32.5 cents in January to 38.5 cents per pound in October.

The total value of shipments for litharge and red and white lead in 1976 was $79.4 million, an increase of $20.0 million from the 1975 total. The average value per ton was $553.71 compared with $427.78 in 1975. The increase in value was attributed to higher pricing in all categories.

Foreign Trade.—Exports of pigment-grade lead oxides and compounds totaled 2,965 tons with a gross value of $2.1 million. Venezuela and Brazil accounted for 57% of the total shipments; the remainder was shipped to 32 other countries. Imports of lead pigments and compounds increased in 1976 to 17,836 tons with a total value of approximately $9.5 million. Litharge accounted for 77% of the tonnage with a value of almost $5.7 million. Mexico was the prime source of supply for litharge accounting for 99.9% of the total. Chrome yellow was second in volume at 2,747 tons; Canada and Japan supplied 73% and 25%, respectively, of the total chrome yellow, with a small quantity from West Germany. The remainder of pigments and compounds was received from a total of 11 countries.

STOCKS

Industry stocks of lead at producers and consumers plants dropped sharply during 1976 from a high level of 206,300 tons in March to a low of 151,800 tons in November. The closing inventory of 171,600 tons at yearend, including refined lead, lead in antimonial lead, and lead in alloys, was 19% less than in 1975.

The downtrend was virtually all reflected in primary producer stocks, which dropped to a low of 43,716 tons in December from a peak of 92,034 tons recorded in February. The decrease was primarily in holdings of refined pig lead, which declined 36,844 tons to a low of 39,869 tons at yearend. Lead in antimonial lead, base bullion, and ore and matte also contributed to the lower stock figures and collectively were 15,143 tons less than the comparable 1975 total. The largest drop in primary producer stocks, other than refined pig lead, was attributed to lead contained in ore and matte, which fell to 54,140 tons, a decline of 14,369 tons from that of 1975.

Consumer and secondary smelter stocks of lead in all forms declined slightly in 1976 to 129,610 tons, a drop of 3,705 tons from 1975. Increased stocks of refined soft lead, alloys, and lead in copper-base scrap were more than offset by a drop in antimonial lead to 34,106 tons, a reduction of 7,463 tons from that of 1975.

Scrap in the hands of all consumers rose about 7% to 101,670 tons. Reduced inventories of soft and hard lead were more than offset by gains in all other categories. The largest increase was in drosses and residues which rose by 4,889 tons to 36,737 tons.

Total stocks of lead in LME warehouses dropped about 19% to 76,058 tons during 1976. The decline from 94,467 tons in January was steady until the end of May when a short upturn through July indicated a slight recovery. However, from this minor peak in July there was a sharp drop to a low of 70,878 tons in late October. Slight gains in inventory continued into December when the stocks began to drop again ending the year on a definite downtrend.

PRICES

The U.S. producer price for common and corroding-grade pig lead as reported by Metals Week on a nationwide, delivered basis, was 19.0 cents per pound through March 9, 1976. Effective March 10, ASARCO raised its price to 20 cents per pound. Several other producers quoted a 2-cent increase to 22 cents per pound on the same day. On April 14, St. Joe Minerals raised its quotation by 2 cents, to a level of 23 cents per pound. St. Joe was quickly followed by all producers with the exception of ASARCO, which announced an increase of 1.5 cents to 22.50 cents per pound on April 15. The split price prevailed through May 13, when ASARCO declared an increase of 0.5 cent per pound, which established all producers at the 23-cent-per-pound level. During July there was a series of price changes, and on July 12, the producer price was established in a split range of 24.50 to 25.00 cents per pound, where it stayed until September 30. On September 30, St. Joe Minerals increased its lead price by 1 cent to 26 cents per pound. The other producers followed this move on October 2, resulting in a split price of 25.50 to 26.00 cents per pound which was maintained through the remainder of the year.

The cash bid price for lead on the LME during the first quarter ranged from 15.2 to 17.4 cents per pound in terms of U.S. currency. The average parity margin was 3.1 cents per pound for the period, indicating that foreign lead could be shipped competitively to the United States. However, in the period covering March through July the LME quotations rose more rapidly than the U.S. producer price and the margins narrowed accordingly. The low price during this period was 20.6 cents per pound and the high was 23.12 cents per pound with a corresponding average difference of 1.2 cents per pound. At this level the cost of freight, duty, brokerage, and profit would not permit the movement of foreign metal to the U.S. market. In August the traditional spread reappeared with the price at 21.8 cents per pound where it remained relatively unchanged through the remainder of the year. The average marginal parity for this 5-month period was about 3.9 cents per pound. The average annual price for lead on the LME in 1976 was 20.46 cents per pound (based on a monthly average Sterling exchange rate of 180.542 cents) compared with the 1975 price of 18.73 cents per pound (basis a Sterling exchange rate of 222.15 cents)

FOREIGN TRADE

Exports of lead metal, lead alloys, and lead in scrap materials in 1976 totaled 52,760 tons, 26% less than in 1975. Metal and alloy exports were reduced substantially but scrap exports at 46,883 tons were down only by 6% and continued to represent a significant outflow of lead. Canada received about 33% of the total exports of metal and scrap, Venezuela received 10%, Taiwan 9%, Mexico 8%, Brazil 7%, and about 32 nations divided the remainder. Shipments of lead and zinc concentrates continued to move overseas, but no statistical division between lead and zinc was available. The gross weight of concentrates was 148,787 tons valued at $28.9 million. Belgium and West Germany together received 59% of the shipments by weight.

Export of gasoline antiknock additives containing tetraethyl lead or tetramethyl lead was estimated to contain 28,000 tons of lead valued at $86.5 million based on trade data from the Bureau of the Census.

General imports of lead, comprising 148,266 tons of metal, 76,365 tons in ores and concentrates, and 4,413 tons in scrap, totaled 18% more than in 1975. Imports of ores and concentrates for consumption totaled 88,988 tons, almost twice those of 1975, reflecting increased withdrawal of material from bond. The principal source countries were Honduras, Peru, Australia, Mexico, and Canada. Imports for consumption of metal were 45% over those of 1975 reversing the declining trend of previous years. Source countries for metal imports were Canada 33%, Mexico 32%, Yugoslavia 14%, Peru 14%, Australia 1% and others 6%.

Basic tariff rates remained unchanged in 1976 at 0.75 cent per pound of lead in ore and concentrates and 1.0625 cents per pound on bullion, metal and dross for most favored nations. The statutory rate of 2.125 cents per pound for other nations remained in effect during 1976.

WORLD REVIEW

World mine production of lead in 1976 declined for the third year to 3.70 million tons, about 1% down from production in 1975. Smelter production, on the other hand, increased by 4% to 3.79 million tons and refined lead consumption reported by the World Bureau of Metal Statistics rose by 9% to 4.69 million tons.

Mine production in 1976 by market economy countries totaled 2.68 million tons, 3% less than in 1975. Smelter production in market economy countries, limited to primary metal where information was available, was 2.73 million tons, a 3% gain over that of 1975. The mine production of centrally planned economy countries, except Yugoslavia, was estimated at 1.02 million tons and smelter production at 1.06 million tons with a small part of the assigned smelter production coming from secondary sources. These estimates indicated a slight increase, less than 1%, from those of 1975.

The United States was the leading country in lead mine production and accounted for 16% of the world total. Other countries producing significant percentages of the total were the U.S.S.R. 14%, Australia 12%, Canada 8%, Mexico 6%, Peru 5%, Yugoslavia 4%, North Korea 4%, Bulgaria 3%, and the People's Republic of China 3%. The United States was also the leading producer of refined lead followed in order by the U.S.S.R., Australia, Japan, Mexico, Canada, France, Yugoslavia, Bulgaria, Belgium, West Germany, and the People's Republic of China. The smelter outputs assigned to Bulgaria, France, and Yugoslavia may include recovery from secondary sources.

Total world consumption of refined lead in 1976 was reported by the World Bureau of Metal Statistics as 4.7 million tons, 9% more than in 1975. This total includes some secondary lead, but excludes remelted pig lead and remelted antimonial lead. If all secondary metal consumption were included, the world total would be in the range of 5.3 to 5.5 million tons. The United States was the leading consuming country using 1.5 million tons and accounting for 27% of the total.

Australia.—Mine production of lead, 439,000 tons in 1976, was 2% less than in 1975. Australia retained its position as the third ranking source of lead in ores and concentrates. The combined production of refined lead and lead bullion, 378,000 tons, was 10% over that of 1975 making Australia third in lead metal production.

The lead dumping case against Australian and Canadian lead producers, started in 1973, was reviewed by the U.S. International Trade Commission early in 1976. In April, the Commission found in favor of the foreign producers with a ruling that allowed them to make less than fair value sales as long as there is no injury to domestic industry. This encouraged refined lead imports from Australia to increase from none in 1975 to 6,123 tons in 1976.

Australian Mining and Smelting Ltd., St. Joe Minerals Corp., and Phelps Dodge Corp. reached an agreement for the development of a zinc-lead-copper deposit in the Woodlawn area of New South Wales. Drilling indicated 10 million tons of ore averaging 9% zinc, 3.5% lead, 1.8% copper, and 56 grams of silver per ton of ore.

North Broken Hill Ltd. continued to prospect a possible extension of its orebody and diamond drill holes showed encouraging results.

Bolivia.—The three mine groups in Bolivia, Corporación Minera de Bolivia (COMIBOL), the medium miners, and the small miners, combined to produce for export over 18,000 tons of lead in concentrate in 1976. COMIBOL was the main producer with 68% of the total production mainly from the Tatasi and Telemayu mines. Plans to construct a lead-silver smelter were advanced with the intention of asking for supplier bids in 1977. The project was to cost $110 million with an estimated capacity of 24,000 tons of lead per year and was to be located near Potosi in southern Bolivia.

Canada.—Mine production of lead, as recoverable content of ores, was 283,000 short tons in 1976, a reduction of 25% from 1975 production and the lowest level of lead mined in 12 years. Production of primary refined lead was 193,000 tons, a 2% increase from output in 1975. Production of secondary lead was about 37,000 tons, slightly more than in 1975.

Lead in Canada was mined as a byproduct or coproduct of zinc, copper, or silver, and production was depressed as the output of zinc and copper was scaled down to suit market conditions. Canadian consumption in 1976 was estimated to be 69,000 tons of primary and 39,000 tons of secondary lead, an increase of 10% from 1975.

Exploration continued in Canada on several base metal deposits containing byproduct or coproduct lead. In New Brunswick, Canex Placer Ltd. was developing its Restigouche and Murray-Brook properties, Anaconda Canada, Ltd., continued feasibility studies on the Caribon property, and Texasgulf Inc. continued diamond drilling at Half Mile Lake, but the exploration shaft was deferred because of poor metallurgical test results. In Yukon Territory, development work continued on the Grum deposit with Kerr Addison Mines Ltd. and Canadian Natural Resources Ltd. concluding a feasibility study looking toward a decision on the next step in 1977. Canex Placer Ltd. had a joint project with United States Steel Corp. drilling the Howards Pass deposit, and Hudson Bay Mining and Smelting Co. Ltd. was exploring and drilling the Tom deposit through an adit. Vangorda Mines Ltd. at Vangorda Creek conducted a feasibility study which indicated that production would probably depend on development of the nearby Grum deposit. In the Northwest Territories, Cominco Ltd. completed its underground work and feasibility study at Arvik on Little Cornwallis Island and future production was to depend on the results of negotiations with the Federal Government. Texasgulf Inc. continued work at Izok Lake, 225 miles north of Yellowknife, with drilling on three separate zones indicating over 12 million tons of ore grading 13.77% zinc, 2.8% copper, and 1.4% lead.

Mine production of lead (recoverable content) came from eight provinces and territories, the four major sources being British Columbia—98,000 tons, New Brunswick—68,000 tons, Northwest Territories—60,000 tons, and Yukon—42,000 tons. Major mine producers of lead in concentrate were Cominco's Sullivan mine in British Columbia—85,000 tons, Cominco's Pine Point mines in Northwest Territories—60,000 tons, Brunswick Mining and Smelting Corp. Ltd. Bathurst mines in New Brunswick—40,700 tons, and Cyprus Anvil Mining Corp. mine at Faro, Yukon—36,500 tons.

Metal production came from two smelters. The Cominco smelter at Trail, British Columbia produced 142,000 tons and the Brunswick Mining and Smelting Corp. plant at Belledune, New Brunswick, produced 51,400 tons of lead. Brunswick is a subsidiary of Noranda Mines, Ltd.

Greenland.—The Black Angel mine in west Greenland was operated by Greenex AG, a subsidiary of Vestgron Mines Ltd., and produced 157,000 tons of zinc concentrate and 42,000 tons of lead concentrate from 663,000 tons of ore assaying 14.7% zinc and 5.2% lead. Cominco Ltd. holds a 61.5% interest and Northgate Exploration Ltd. a 9.6% interest in Vestgron.

Ireland.—Tara Exploration and Development Co. Ltd. at Navan, County Meath, planned to begin production of zinc and lead concentrates early in 1977. Tara is owned in part by a consortium of mining companies: Noranda Mines Ltd. 19.93%; Cominco, Ltd. 17.43%; Charter Consolidated Ltd. 10.75%; Northgate Exploration Ltd. 9.9%; and the remaining interest is held by the Irish Government and other private investors. The mine was expected to produce about 500,000 tons of concentrates per year in the ratio of 5 parts of zinc to 1 part lead.

Bula Ltd., controlling the northern part of the deposit at Navan, planned to begin construction of its separate concentrator in 1977. The Tynagh lead-zinc-silver mine in County Galway, owned by Irish Base Metals Ltd., continued production of concentrates in 1976. A total of 27,000 tons of lead concentrate and 26,000 tons of zinc concentrate were shipped to European smelters. Kerr Addison Mines Ltd. acquired a 75% interest in the Silvermines property in County Tipperary (formerly Mogul of Ireland Ltd.) in March 1976. The Mogul or Silvermines mine produced zinc and lead concentrates containing 54,760 tons of zinc and 14,870 tons of lead (metal content).

The total lead production in Ireland in 1976 was estimated to be 35,000 tons.

Japan.—Production of refined lead increased by 13% to over 241,000 tons in 1976 as better demand developed from the automobile and construction industries. A strike at Cyprus Anvil Mining Corp. in Yukon, Canada, forced Toho Zinc Co. Ltd. to purchase metal and concentrates elsewhere to keep its lead plant operating. The domestic mine production of Japan was about 57,000 tons of lead in concentrates, one-fourth of total metal requirements. The Ministry of International Trade and Industry (MITI) planned to begin a stockpile of nonferrous metals including lead. The objective for lead was 9,900 tons but no purchases were scheduled for 1976. Japan, often an exporter of lead, imported 35,000 tons in 1976 against exports of 9,500 tons.

Mexico.—Regulations fulfilling the Mining Law of 1975 were issued in November 1976. A compromise was reached in negotiations between the Government and Camara Minera de Mexico (CMM) representing the private mining firms in Mexico. If these regulations were strictly enforced, Government ownership or participation in mining enterprises would increase, entry of foreign capital would be permitted only on a minority basis, and expansion by private enterprises could be limited.

During 1976, Industrias Peñoles S. A. announced plans to market about 40% of its refined lead production in the United States. The new silver-lead refinery at Torreon was completed in January but startup problems prevented normal production until late in the year.

Industrial Minera Mexico S.A. (IMM) completed the modernization of three of its major mines increasing its capacity to produce lead-zinc ores. During 1976 it produced 96,800 tons of lead metal from the smelter in Chihuahua and refinery in Monterrey.

Until recently Mexico was a source of lead concentrates and flue dusts imported into the United States, but in 1975 and 1976 practically none appeared in general imports. On the other hand, lead imported in pigs and bars was 44,290 tons in 1976, a 49% increase over imports in 1975 representing 21% of Mexico's total lead metal production in 1976.

South Africa, Republic of.—The Republic of South Africa produced only a few thousand tons of lead concentrate from the Prieska mine in 1976. However, exploration at the Broken Hill and Black Mountain holdings of the Phelps Dodge Corp. near Aggeneys in northwest Cape Province disclosed ore reserves that could make South Africa a substantial lead producer. Reports indicated that Broken Hill reserves were over 79 million tons of ore averaging 0.38% copper, 4.28% lead, 2.32% zinc, and 1.7 ounces of silver per ton; Black Mountain contained 30 million tons averaging 0.60% copper, 2.30% lead, 0.5% zinc, and 0.73 ounce of silver per ton. Most of this tonnage is amenable to open pit mining. A feasibility study indicated that the project could produce 145,000 tons per year of lead concentrates within 3 or 4 years if transportation and water supply facilities can be arranged.

Yugoslavia.—Exploration for new mines and expansion of existing lead-zinc mines was planned as part of a program designed to double 1975 production of lead raw materials by 1980. The aim of the program was to eliminate the need for imports of concentrates to keep Yugoslavian smelters producing at capacity. A new lead mine was brought into production late in 1976 and expansion continued at three other mine-mill units. During 1976 about 18 mines and 14 flotation plants were producing. Two lead smelters, one lead refinery, and one lead-zinc Imperial smelting furnace were in operation. Exports of lead from Yugoslavia to the United States totaled 19,944 tons, 16% of Yugoslavia's total refined lead production. Trepca was the largest lead-zinc producing entity, operating the Stari Trg mine and lead smelter and refinery at Zvecan.

TECHNOLOGY

Much of recent technological progress with respect to lead was related to the solution of environmental problems including control of toxic emissions from smelters and the treatment of solid and liquid wastes from mines and mills, foundries, and lead fabricating plants to reduce or eliminate health hazards.

The Bureau of Mines began to evaluate the economic feasibility of its newly developed hydrometallurgical process for extracting lead, zinc, and associated metals from sulfide mineral concentrates in a continuous pilot plant operation. The process, which uses a ferric chloride-brine leach and fused-salt electrolysis procedure to recover lead from galena concentrates, produces metallic lead without generating sulfur oxides and minimizes the emission of lead vapors.

Several direct smelting processes for treating lead concentrate to produce metallic lead and slag have been developed in recent years to the pilot plant stage. These processes offer several potential advantages over blast furnace smelting by eliminating the sintering operation, reducing fuel requirements due to the use of exothermic heat of smelting reactions, and producing a richer SO_2 gas than is obtainable with sintering. One of these processes, the Q-S process being tested by St. Joe Minerals, is based on autogenous flash oxidation of the lead concentrate followed by submerged oxygen injection into the bath in a long reactor vessel. Lead is recovered as PbS, which redissolves in the bullion under the slag. The process produces bullion and SO_2 in such concentrations that air pollution can be minimized. In a further development of the Q-S process by Lurgi GmbH, designated the QSL lead recovery process, pelletized concentrates are continuously charged into a reactor in which injected oxygen produces rapid melting due to intense oxidation. Lead metal is recovered with a slag low in lead for rejection to waste. Reported advantages of the process include lower capital investment, less unit equipment and lower operating costs compared with conventional processes.[12]

The Kivcet-CS process for treating lead sulfide concentrate, developed to industrial scale in the U.S.S.R., combined the functions of sintering, blast furnacing and slag fuming in one autogenous smelting operation. The process is reportedly characterized by high metal recoveries, low environmental contamination, and low labor and capital costs compared with a conventional smelter.[13]

A flash agglomeration method of treating flue dust produced in smelting scrap automobile batteries developed by Paul Bergsoe and Son Co., Denmark, reduces airborne emissions of sulfur and lead particulates to allowable limits. By a closed conveyor, flue dust from the baghouse hopper is transported directly into a flash agglomeration furnace, forming a molten slag which is tapped from the furnace and allowed to solidify. The agglomerated material is recycled to the smelter furnace with no flue dust leaving the system, thus minimizing health hazards associated with toxic substances contained in the dust.[14]

Significant progress was made in developing lighter weight, more efficient lead-acid batteries in an effort to improve the power-to-weight ratio and expand the market for these batteries in the field of transportation. Notable advances were made toward increasing the oxide-to-metal ratio and improving grid patterns. New grid alloys were developed through research that give promise for use in longer life maintenance-free batteries. Some of the newer alloys contain such elements as strontium and cadmium in addition to those that contain calcium, tin, and antimony.[15]

Hecla Mining Co. in cooperation with the Bureau of Mines developed a technique of destressing blasting to reduce rock bursts in the Star mine. The combination of mining depth, rugged surface terrain, and geological conditions has imposed high residual horizontal stress in the rocks which, influenced by mine openings and rock composition, creates a favorable environment for rock bursts. Guided by seismic monitoring the destressing blasting consists of drilling long holes into vein walls and blasting to relieve stress on walls ahead of stoping.[16]

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[12] Matyas, A. G., and P. J. Mackey. Metallurgy of the Direct Smelting of Lead. J. Metals, November 1976, pp. 10-15.

[13] Muller, E. How Kivcet CS Shaft Furnace Simultaneously Smelts Pb-Zn. World Mining, v. 30, No. 4, April 1977, pp. 46-49.

[14] Mackey, T. S., and S. Bergsoe. Smelting of Unbroken Batteries. Presented at 106th Ann. Meeting, AIME, Atlanta, Ga., March 1977.

[15] Casserio, M. G. An Auto Manufacturers' Overview of the Battery Market. Convention "77." Battery Council International, Washington, D.C., April 1977, pp. 28-31.

[16] World Mining. Destressing Vein Walls in Star Mine To Minimize Rock Bursts. V. 30. No. 6, June 1977, p. 45.

Table 2.—Mine production of recoverable lead in the United States, by State

(Short tons)

State	1972	1973	1974	1975	1976
Alaska	--	6	--	--	14
Arizona	1,763	763	1,059	420	338
California	1,153	44	35	66	54
Colorado	31,346	28,112	24,609	27,088	26,749
Idaho	61,407	61,744	51,717	50,395	53,636
Illinois	1,335	541	493	W	W
Kentucky	--	--	--	([1])	--
Maine	85	204	279	364	216
Missouri	489,397	487,143	562,097	515,958	500,991
Montana	287	176	154	205	92
Nevada	([1])	--	1,785	2,976	582
New Mexico	3,582	2,556	2,364	1,931	W
New York	1,089	2,304	3,076	3,027	3,196
Oklahoma	--	--	W	--	W
Oregon	--	--	W	W	--
Utah	20,706	13,733	10,510	12,679	16,297
Virginia	3,441	2,637	3,106	2,551	1,946
Washington	2,567	2,217	1,299	W	W
Wisconsin	757	844	1,285	W	W
Other States	--	--	2	3,804	5,435
Total	618,915	603,024	663,870	621,464	609,546

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1]Less than 1/2 unit.

Table 3.—Production of lead and zinc in the United States in 1976, by State and class of ore, from old tailings, etc., in terms of recoverable metal

(Short tons)

State	Lead ore			Zinc ore			Lead-zinc ore		
	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content
Alaska	78	14	--	--	--	--	--	--	--
Arizona	213	11	1	--	--	--	1,100	45	114
California	--	--	--	2,300	46	164	--	--	--
Colorado	206	13	--	178,945	1,658	12,908	521,216	15,244	24,761
Idaho	187,733	19,461	2,315	([1])	([1])	([1])	1,129,543	33,080	42,061
Kentucky	--	--	--	--	--	--	--	--	--
Maine	--	--	--	--	--	--	--	--	--
Missouri	8,657,845	500,991	83,530	--	--	--	--	--	--
Montana	488	28	5	35	--	1	--	--	--
Nevada	--	--	--	8,300	33	320	77,450	516	1,110
New Jersey	--	--	--	207,900	--	33,767	--	--	--
New York	--	--	--	1,239,456	3,196	73,671	--	--	--
Pennsylvania	--	--	--	521,072	--	22,280	--	--	--
Tennessee	--	--	--	3,125,452	--	78,218	--	--	--
Utah	3,621	577	--	--	--	--	366,140	15,720	22,481
Virginia	--	--	--	522,443	1,946	11,241	--	--	--
Other States[2]	150	11	--	581,803	3,126	22,164	380,581	2,037	12,793
Total	8,850,334	521,106	85,851	6,387,706	10,005	254,734	2,476,030	66,642	103,320
Percent of total lead-zinc	--	85	18	--	2	53	--	11	21

State	Copper-lead, copper-zinc, and copper-lead-zinc ores			All other sources[3]			Total		
	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content
Alaska	--	--	--	--	--	--	78	14	--
Arizona	90,278	--	9,350	65,269,628	282	36	65,361,219	338	9,501
California	--	--	--	3,774	8	6	6,074	54	170
Colorado	361,250	7,143	11,940	197,860	2,691	1,012	1,259,477	26,749	50,621
Idaho	([1])	([1])	([1])	[1]501,678	[1]1,095	[1]2,210	1,818,954	53,636	46,586

See footnotes at end of table.

Table 3.—Production of lead and zinc in the United States in 1976, by State and class of ore, from old tailings, etc., in terms of recoverable metal —Continued

(Short tons)

State	Copper-lead, copper-zinc, and copper-lead-zinc ores			All other sources[3]			Total		
	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content
Kentucky	--	--	--	58,794	--	59	58,794	--	59
Maine	176,079	216	7,810	--	--	--	176,079	216	7,810
Missouri	--	--	--	--	--	--	8,657,845	500,991	88,530
Montana	--	--	--	6,380	64	58	6,903	92	64
Nevada	--	--	--	1,717,575	33	8	1,803,325	582	1,438
New Jersey	--	--	--	--	--	--	207,900	--	33,767
New York	--	--	--	--	--	--	1,239,456	3,196	73,671
Pennsylvania	--	--	--	--	--	--	521,072	--	22,280
Tennessee	2,034,015	--	4,294	--	--	--	5,159,467	--	82,512
Utah	--	--	--	120	--	--	369,881	16,297	22,481
Virginia	--	--	--	--	--	--	522,443	1,946	11,241
Other States[2]	130	2	2	2,819,782	259	3,823	3,782,446	5,435	38,782
Total	2,661,752	7,361	33,396	70,575,591	4,432	7,212	90,951,413	609,546	484,513
Percent of total lead-zinc	--	1	7	--	1	1	--	100	100

[1]Zinc ore, copper-lead ore, and ore from "Other sources" combined to avoid disclosing individual company confidential data.
[2]Other States includes Illinois, New Mexico, Oklahoma, Washington, and Wisconsin.
[3]Lead and zinc recovered from copper, gold, silver, and fluorspar ores, and from mill tailings and miscellaneous cleanups.

Table 4.—Mine production of recoverable lead in the United States, by month

(Short tons)

Month	1975	1976	Month	1975	1976
January	55,578	50,379	August	48,065	50,978
February	52,575	51,999	September	50,640	49,200
March	58,485	57,751	October	56,327	49,615
April	56,005	50,565	November	49,019	48,975
May	53,277	50,959	December	52,858	50,429
June	50,813	50,560	Total	621,464	609,546
July	37,822	48,136			

Table 5.—Twenty-five leading lead-producing mines in the United States in 1976, in order of output

Rank	Mine	County and State	Operator	Source of lead
1	Buick	Iron, Mo	AMAX Lead Co. of Missouri.	Lead ore.
2	Fletcher	Reynolds, Mo	St. Joe Minerals Corp	Do.
3	Magmont	Iron, Mo	Cominco American, Inc	Do.
4	Ozark	Reynolds, Mo	Ozark Lead Co	Do.
5	Brushy Creek	do	St. Joe Minerals Corp	Do.
6	Viburnum No. 29	Washington, Mo	do	Do.
7	Viburnum No. 28	Iron, Mo	do	Do.
8	Indian Creek	Washington, Mo	do	Do.
9	Lucky Friday	Shoshone, Idaho	Hecla Mining Co	Do.
10	Bunker Hill	do	The Bunker Hill Co	Lead-zinc ore.
11	Star Unit	do	Hecla Mining Co	Do.
12	Ontario	Summit, Utah	Park City Ventures	Do.
13	Viburnum No. 27	Crawford, Mo	St. Joe Minerals Corp	Lead ore.
14	Leadville Unit	Lake, Colo	ASARCO Inc	Lead-zinc ore.
15	Idarado	Ouray and San Miguel, Colo	Idarado Mining Co	Copper-lead-zinc ore.
16	Burgin	Utah, Utah	Kennecott Copper Corp	Lead-zinc ore.
17	Sunnyside	San Juan, Colo	Standard Metals Corp	Do.
18	Balmat	St. Lawrence, N.Y	St. Joe Minerals Corp	Zinc ore.
19	Ground Hog	Grant, N. Mex	ASARCO Inc	Do.
20	Bulldog Mountain	Mineral, Colo	Homestake Mining Co	Silver ore.
21	Camp Bird	Ouray, Colo	Federal Resources Corp	Lead-zinc ore.
22	Pend Oreille	Pend Oreille, Wash	The Bunker Hill Co	Do.
23	Austinville and Ivanhoe	Wythe, Va	The New Jersey Zinc Co.	Zinc ore.
24	Eagle	Eagle, Colo	do	Zinc and silver ore.
25	Emperius	Mineral, Colo	Minerals Engineering Co.	Lead-zinc ore.

Table 6.—Refined lead produced at primary refineries in the United States, by source material

(Short tons)

	1972	1973	1974	1975	1976
Refined lead:[1]					
From primary sources:					
Domestic ores and base bullion	577,398	567,256	580,078	530,215	568,536
Foreign ores and base bullion	103,001	107,260	92,946	105,907	84,341
Total	680,399	674,516	673,024	636,122	652,877
From secondary sources	1,189	--	--	--	29
Grand total	681,588	674,516	673,024	636,122	652,906
Calculated value of primary refined lead (thousands)[2]	$204,528	$219,757	$303,265	$273,914	$301,643

[1]GSA metal is not included in refined lead production.
[2]Value based on average quoted price and excludes value of refined lead produced from scrap at primary refineries.

Table 7.—Antimonial lead produced at primary lead refineries in the United States

Year	Production (short tons)	Antimony content		Lead content by difference (short tons)			
		Short tons	Percent	From domestic ore	From foreign ore	From scrap	Total
1972	15,051	1,050	7.0	6,136	2,049	5,816	14,001
1973	15,455	1,167	7.5	9,020	4,203	1,065	14,288
1974	12,513	1,097	8.8	5,879	3,988	1,549	11,416
1975	6,029	567	9.4	1,658	467	3,337	5,462
1976	6,743	730	10.8	2,314	2,328	1,371	6,013

Table 8.—Stocks and consumption of new and old lead scrap in the United States in 1976

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and refiners:						
Soft lead	3,090	37,721	--	38,842	38,842	1,969
Hard lead	2,674	34,936	--	36,431	36,431	1,179
Cable lead	724	51,249	--	48,073	48,073	3,900
Battery-lead plates	54,153	689,212	--	689,008	689,008	54,357
Mixed common babbitt	155	3,466	--	3,366	3,366	255
Solder and tinny lead	216	10,746	--	10,586	10,586	376
Type metals	2,389	20,116	--	19,613	19,613	2,892
Drosses and residues	31,848	156,010	151,121	--	151,121	36,737
Total	95,249	1,003,456	151,121	845,919	997,040	101,665
Foundries and other manufacturers:						
Soft lead	--	--	--	--	--	--
Hard lead	--	--	--	--	--	--
Cable lead	--	--	--	--	--	--
Battery-lead plates	--	--	--	--	--	--
Mixed common babbitt	5	6,068	--	6,068	6,068	5
Solder and tinny lead	--	--	--	--	--	--
Type metals	--	--	--	--	--	--
Drosses and residues	--	--	--	--	--	--
Total	5	6,068	--	6,068	6,068	5
All consumers:						
Soft lead	3,090	37,721	--	38,842	38,842	1,969
Hard lead	2,674	34,936	--	36,431	36,431	1,179
Cable lead	724	51,249	--	48,073	48,073	3,900
Battery-lead plates	54,153	689,212	--	689,008	689,008	54,357
Mixed common babbitt	160	9,534	--	9,434	9,434	260
Solder and tinny lead	216	10,746	--	10,586	10,586	376
Type metals	2,389	20,116	--	19,613	19,613	2,892
Drosses and residues	31,848	156,010	151,121	--	151,121	36,737
Grand total	95,254	1,009,524	151,121	851,987	1,003,108	101,670

Table 9.—Secondary metal recovered[1] from lead and tin scrap in the United States in 1976, by type of product

(Short tons)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	220,953	--	--	--	220,953
Remelt lead	90,057	--	--	--	90,057
Total	311,010	--	--	--	311,010
Refined pig tin	--	1,596	--	--	1,596
Remelt tin	--	24	--	--	24
Total	--	1,620	--	--	1,620
Lead and tin alloys:					
Antimonial lead	341,967	604	16,498	412	359,481
Common babbitt	11,619	487	886	4	12,996
Genuine babbitt	36	59	7	1	103
Solder	24,363	4,975	658	21	30,017
Type metals	14,545	736	1,662	1	16,944
Cable lead	8,959	--	84	--	9,043
Miscellaneous alloys	330	54	4	--	388
Total	401,819	6,915	19,799	439	428,972
Tin content of chemical products	--	467	--	--	467
Grand total	712,829	9,002	19,799	439	742,069

[1]Most of the figures herein represent actual reported recovery of metal from scrap.

Table 10.—Secondary lead recovered in the United States

(Short tons)

	1972	1973	1974	1975	1976
As metal:					
At primary plants	1,189	--	--	--	29
At other plants	172,168	186,124	238,216	271,297	310,981
Total	173,357	186,124	238,216	271,297	311,010
In antimonial lead:					
At primary plants	5,816	1,065	1,549	3,337	1,371
At other plants	340,066	374,713	369,954	311,783	340,596
Total	345,882	375,778	371,503	315,120	341,967
In other alloys	97,358	92,384	88,979	72,039	73,592
Grand total:					
Quantity	616,597	654,286	698,698	658,456	726,569
Value (thousands)	$185,349	$213,166	$314,833	$283,531	$335,675

Table 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1975	1976	Form of recovery	1975	1976
New scrap:			As soft lead:		
Lead-base	90,712	100,750	At primary plants	--	29
Copper-base	3,252	3,420	At other plants	271,297	311,010
Tin-base	250	165	Total	271,297	311,039
Total	94,214	104,335			
Old scrap:					
Battery-lead plates	417,489	461,391	In antimonial lead[1]	315,120	341,967
All other lead-base	136,280	148,981	In other lead alloys	58,485	59,502
Copper-base	10,471	11,860	In copper-base alloys	13,523	14,025
			In tin-base alloys	31	36
Tin-base	2	2	Total	387,159	415,530
Total	564,242	622,234	Grand total	658,456	726,569
Grand total	658,456	726,569			

[1]Includes 3,337 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1975 and 1,371 in 1976.

Table 12.—Lead consumption in the United States, by product

(Short tons)

Product	1975	1976	Product	1975	1976
Metal products:			Pigments—Continued:		
Ammunition	75,081	73,478	Pigment colors	10,618	16,634
Bearing metals	12,184	13,063	Other[1]	499	561
Brass and bronze	13,404	15,660	Total	79,072	105,591
Cable covering	22,099	15,930	Chemicals:		
Calking lead	14,296	12,475	Gasoline antiknock additives	208,605	239,758
Casting metals	7,711	6,708	Miscellaneous chemicals	181	146
Collapsible tubes	2,216	2,329	Total	208,786	239,904
Foil	3,205	5,126	Miscellaneous uses:		
Pipes, traps, bends	14,233	13,789	Annealing	2,629	2,893
Sheet lead	24,859	24,438	Galvanizing	1,228	1,252
Solder	57,344	63,324	Lead plating	376	386
Storage batteries:					
Battery grids, posts, etc	326,714	383,844	Weights and ballast	20,018	22,366
Battery oxides	372,700	438,560	Total	24,251	26,897
Terne metal	1,511	1,595	Other, unclassified uses	21,221	32,354
Type metal	16,211	15,007	Grand total[2]	1,297,098	1,490,072
Total	963,768	1,085,326			
Pigments:					
White lead	2,498	2,993			
Red lead and litharge	65,457	85,403			

[1]Includes lead content of leaded zinc oxide and other pigments

[2]Includes lead that went directly from scrap to fabricated products.

Table 13.—Lead consumption in the United States, by month

(Short tons)

Month	1975	1976	Month	1975	1976
January	105,091	116,253	August	115,510	120,656
February	98,866	123,270	September	122,985	127,399
March	99,216	136,065	October	133,696	137,447
April	105,105	125,735	November	115,757	128,009
May	102,255	123,381	December	115,323	125,152
June	94,700	123,335	Total[1]	1,297,098	1,490,072
July	88,594	103,370			

[1]Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide and other pigments.

Table 14.—Lead consumption in the United States in 1976, by class of product and type of material

(Short tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	151,652	51,887	47,796	11,587	262,922
Storage batteries	461,111	357,759	3,534	--	822,404
Pigments	105,369	222	--	--	105,591
Chemicals	239,904	--	--	--	239,904
Miscellaneous	13,660	13,216	21	--	26,897
Unclassified	29,067	2,415	872	--	32,354
Total	1,000,763	425,499	52,223	11,587	[1]1,490,072

[1]Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide and other pigments.

Table 15.—Lead consumption in the United States in 1976, by State[1]

(Short tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	111,152	40,852	4,575	317	156,896
Colorado	368	227	35	--	630
Connecticut	10,819	7,854	--	861	19,534
District of Columbia	104	--	--	--	104
Florida	10,845	9,408	246	--	20,499
Georgia	65,128	29,086	738	5	94,957
Illinois	86,450	36,333	8,901	1,297	132,981
Indiana	117,680	35,106	2,829	334	155,949
Kansas	21,892	13,733	68	89	35,782
Kentucky	6,417	9,054	2	--	15,473
Maryland	587	1,679	2,053	13	4,332
Massachusetts	1,153	238	6	212	1,609
Michigan	15,451	15,656	2,996	54	34,157
Missouri	21,227	11,501	1,405	1,107	35,240
Nebraska	1,621	1,232	1,021	1,072	4,946
New Jersey	104,179	10,886	3,346	454	118,865
New York	33,339	5,239	4,158	190	42,926
Ohio	10,593	4,974	3,872	1,623	21,062
Pennsylvania	98,524	58,661	10,833	1,693	169,711
Rhode Island	3,748	327	8	--	4,083
Tennessee	4,092	18,620	64	50	22,826
Virginia	408	2,468	1,039	527	4,442
Washington	7,501	2,546	--	--	10,047
West Virginia	13,144	410	--	--	13,554
Wisconsin	5,714	9,909	73	283	15,979
Alabama and Mississippi	3,993	7,121	--	590	11,704
Arkansas and Oklahoma	2,974	4,749	--	--	7,723
Hawaii and Oregon	10,375	7,194	--	--	17,569
Iowa and Minnesota	12,432	18,602	1,216	52	32,302
Louisiana and Texas	190,320	35,056	1,843	655	227,874
Montana and Idaho	720	--	--	--	720
New Hampshire, Maine, Vermont, Delaware	10,935	12,106	638	109	23,788
North and South Carolina	16,876	12,733	--	--	29,609
Utah, Nevada, Arizona	2	1,939	258	--	2,199
Total	1,000,763	425,499	52,223	11,587	1,490,072

[1]Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide and other pigments.

Table 16.—Production and shipments of lead pigments[1] and oxides in the United States

Product	1975 Production (short tons)	1975 Shipments Short tons	1975 Shipments Value[2] Total	1975 Shipments Value[2] Average per ton	1976 Production (short tons)	1976 Shipments Short tons	1976 Shipments Value[2] Total	1976 Shipments Value[2] Average per ton
White lead, dry	3,381	3,381	$2,748,194	$813	1,640	1,625	$1,054,436	$649
Red lead	19,447	15,095	7,618,430	505	19,608	19,296	11,146,722	578
Litharge	133,528	120,475	49,073,653	407	132,172	122,462	67,190,997	549
Black oxide	367,532	--	--	--	392,911	--	--	--

[1]Excludes basic lead sulfate; withheld to avoid disclosing individual company confidential data.
[2]At plant, exclusive of container.

Table 17.-Lead content of lead and zinc pigments[1] and lead oxides produced by domestic manufacturers, by source

(Short tons)

Product	1975 Lead in pigments produced from— Ore Domestic	1975 Ore Foreign	1975 Pig lead	1975 Total lead in pigments	1976 Lead in pigments produced from— Ore Domestic	1976 Ore Foreign	1976 Pig lead	1976 Total lead in pigments
White lead	--	--	2,705	2,705	--	--	1,312	1,312
Red lead	--	--	17,629	17,629	--	--	17,775	17,775
Litharge	--	--	124,181	124,181	--	--	122,920	122,920
Black oxide	--	--	351,171	351,171	--	--	374,761	374,761
Total	--	--	495,686	495,686	--	--	516,768	516,768

[1]Excludes lead in basic lead sulfate and leaded zinc oxide; withheld to avoid disclosing individual company confidential data.

Table 18.—Distribution of white lead (dry and in oil) shipments,[1] by industry

(Short tons)

Industry	1972	1973	1974	1975	1976
Paints	6,768	3,198	--	--	--
Ceramics	31	18	--	--	--
Other	3,267	6,328	5,905	3,381	1,625
Total	10,066	9,544	5,905	3,381	1,625

[1]Excludes basic lead sulfate; figures withheld to avoid disclosing individual company confidential data.

Table 19.—Distribution of red lead shipments, by industry

(Short tons)

Industry	1972	1973	1974	1975	1976
Paints	4,909	6,509	5,344	4,552	7,071
Storage batteries	W	W	W	W	W
Other	14,864	9,514	7,946	10,543	12,225
Total	19,773	16,023	13,290	15,095	19,296

W Withheld to avoid disclosing individual company confidential data; included with "Other."

Table 20.—Distribution of litharge shipments, by industry

(Short tons)

Industry	1972	1973	1974	1975	1976
Ceramics	23,188	35,910	46,598	33,941	32,300
Insecticides	W	W	W	W	--
Oil refining	1,262	620	765	W	W
Paints	7,316	3,112	5,347	3,248	8,354
Rubber	2,162	5,078	6,490	5,850	3,820
Other	113,694	134,424	102,245	77,436	77,988
Total	147,622	179,144	161,445	120,475	122,462

W Withheld to avoid disclosing individual company confidential data; included with "Other."

Table 21.—U.S. imports for consumption of lead pigments and compounds

Kind	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
White lead	159	$160	134	$156
Red lead	448	180	881	386
Litharge	12,011	4,449	13,694	5,662
Chrome yellow	2,473	2,437	2,747	2,935
Other lead pigments	36	60	91	93
Other lead compounds	210	184	289	230
Total	15,337	7,470	17,836	9,462

Table 22.—Stocks of lead at primary smelters and refineries in the United States, Dec. 31

(Short tons)

Stocks	1972	1973	1974	1975	1976
Refined pig lead	60,840	22,018	34,116	76,713	39,869
Lead in antimonial lead	3,626	4,062	3,138	4,560	3,847
Lead in base bullion	11,514	8,845	5,492	6,748	6,687
Lead in ore and matte	69,593	54,922	78,305	68,509	54,140
Total	145,573	89,847	121,051	156,530	104,543

Table 23.—Stocks of lead at consumers and secondary smelters in the United States, Dec. 31, by type of material

(Short tons, lead content)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1972	74,161	36,157	6,977	1,249	118,544
1973	84,274	32,226	6,954	667	124,121
1974	106,245	49,504	9,628	1,212	166,589
1975	85,110	41,569	5,059	1,577	133,315
1976	87,774	34,106	6,000	1,730	129,610

Table 24.—Average monthly and yearly quoted prices of lead[1]

(Cents per pound)

Month	1975 U.S. producer	1975 London Metal Exchange	1976 U.S. producer	1976 London Metal Exchange
January	24.50	24.38	19.00	15.24
February	24.50	24.55	19.00	15.80
March	24.50	24.62	20.22	17.36
April	24.50	21.73	21.93	20.61
May	23.34	19.11	22.88	21.85
June	19.00	15.99	23.00	21.60
July	19.00	16.27	24.25	23.12
August	19.56	17.38	24.76	21.83
September	20.00	16.33	24.83	21.75
October	20.00	15.62	25.75	21.05
November	20.00	15.27	25.79	20.81
December	19.46	15.10	25.82	21.66
Average	21.53	18.73	23.10	20.46

[1]Metals Week. Quotations for United States on a nationwide, delivered basis.

Table 25.—U.S. exports of lead, by country[1]

Destination	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Unwrought lead and lead alloys:				
Argentina	58	$53	43	$17
Belgium-Luxembourg	4,331	1,693	1	1
Brazil	3	3	3	2
Canada	512	155	576	279
Chile	3	30	18	22
Colombia	337	174	--	--
Dominican Republic	88	42	51	27
Ecuador	--	--	14	8
Egypt	111	72	--	--
France	1	1	([2])	1
Germany, West	124	80	23	15
Greece	--	--	([2])	1
Honduras	3	3	4	4
Hong Kong	--	--	1	4
Italy	35	17	83	50
Jamaica	43	22	21	12
Japan	479	193	101	126
Korea, Republic of	169	74	31	27
Mexico	136	95	1,005	542
Netherlands	10,455	4,867	--	--
Paraguay	64	22	6	2
Philippines	40	33	69	49
Singapore	([2])	([2])	([2])	3
South Africa, Republic of	111	38	--	--
Taiwan	165	197	8	11
Thailand	9	5	25	11
Trinidad and Tobago	5	4	1	1
U.S.S.R	118	261	78	143
United Kingdom	87	103	50	89
Venezuela	867	36	405	220
Other	34	77	233	201
Total	18,388	8,350	2,850	1,868
Wrought lead and lead alloys:				
Australia	11	49	24	123
Austria	23	22	13	20
Belgium-Luxembourg	534	234	607	171
Brazil	143	446	([2])	26
Canada	866	508	1,088	636
Colombia	50	57	2	4
Costa Rica	15	93	12	114
Denmark	18	23	3	4
Dominican Republic	30	57	16	63
Ecuador	41	55	40	38

See footnotes at end of table.

Table 25.—U.S. exports of lead, by country[1] —Continued

Destination	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Wrought lead and lead alloys: —Continued				
France	10	$44	48	$79
Germany, West	146	206	29	139
Honduras	53	51	137	123
Hong Kong	2	4	(2)	4
Iran	46	36	3	6
Israel	3	4	--	--
Italy	40	52	32	35
Jamaica	2	15	2	5
Japan	44	109	46	166
Korea, Republic of	10	7	99	53
Leeward and Windward Islands	--	--	49	51
Mexico	161	348	165	407
Netherlands	53	79	32	18
Panama	20	56	27	67
Philippines	23	38	19	49
Saudi Arabia	3	13	31	36
Sweden	27	37	24	35
Taiwan	16	74	95	228
United Kingdom	126	268	58	120
Venezuela	186	284	97	154
Vietnam	5	77	--	--
Other	161	345	229	478
Total	2,868	3,691	3,027	3,452
Scrap:				
Belgium-Luxembourg	1,535	335	993	402
Brazil	1,744	417	3,768	860
Canada	16,798	2,759	15,804	2,679
Denmark	1,876	521	1,798	661
Germany, West	317	170	2,877	714
Greece	355	74	--	--
Hong Kong	--	--	39	8
Italy	128	95	1,819	470
Jamaica	200	43	--	--
Japan	1,228	328	1,512	691
Korea, Republic of	2,397	316	3,208	1,259
Malaysia	--	--	133	19
Mexico	2,874	609	2,833	493
Netherlands	5,371	1,006	344	187
Pakistan	40	29	--	--
Singapore	109	14	--	--
South Africa, Republic of	2,715	563	--	--
Spain	1	2	815	205
Taiwan	4,883	911	4,671	1,007
Thailand	446	79	--	--
Turkey	2,403	445	--	--
United Kingdom	1,452	627	945	470
Venezuela	2,974	625	4,805	1,209
Other	105	95	519	205
Total	49,951	10,063	46,883	11,539
Grand total	71,207	22,104	52,760	16,859

[1]In addition foreign lead was reexported as follows: 1975—Unwrought lead and lead alloys, 213 tons ($12,770); wrought lead and lead alloys 18 tons ($15,388) and 1976—Unwrought lead and lead alloys, 859 tons ($793,941), wrought lead and lead alloys, 12 tons ($11,724).
[2]Less than 1/2 unit.

Table 26.—U.S. exports of lead, by class

Year	Blocks, pigs, anodes, etc.				Wrought lead and lead alloys				Scrap	
	Unwrought		Unwrought alloys		Sheets, plates, rods, other forms		Foil, powder, flakes			
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	46,030	$20,512	7,558	$4,836	7,933	$6,696	461	$641	59,366	$16,813
1975	17,455	7,361	933	989	2,695	3,306	173	385	49,951	10,063
1976	2,226	1,307	624	561	2,735	2,927	292	525	46,883	11,539

Table 27.—U.S. imports[1] of lead, by country

Country	1974 Quantity (short tons)	1974 Value (thousands)	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Ore, flue dust, and residues, n.s.p.f. (lead content):						
Australia	19,341	$6,446	15,916	$4,979	11,215	$3,316
Canada	16,035	4,880	28,949	8,618	27,673	8,604
Colombia	35	15	112	42	226	68
Greenland	--	--	6,552	2,031	5,104	1,582
Honduras	18,520	7,645	19,153	5,638	22,028	9,219
Ireland	34	5	--	--	--	--
Mexico	10,631	4,186	--	--	92	28
Nicaragua	3,493	1,518	1,182	509	762	323
Peru	26,201	8,536	15,696	5,328	9,263	2,422
Other	9	9	--	--	2	([2])
Total	94,299	33,240	87,560	27,145	76,365	25,562
Base bullion (lead content):						
Belgium-Luxembourg	--	--	19	7	72	37
Canada	831	331	65	31	730	360
Mexico	--	--	378	145	1,532	558
Total	831	331	462	183	2,334	955
Pigs and bars (lead content):						
Australia	3,308	1,537	--	--	[3]6,123	[3]2,389
Belgium-Luxembourg	1,338	1,106	2,058	1,141	168	93
Canada	40,100	18,578	30,688	14,659	47,612	21,660
China, People's Republic of	--	--	28	111	--	--
Denmark	198	226	420	450	429	627
France	50	54	29	29	33	27
Germany, East	81	169	--	--	--	--
Germany, West	544	2,845	2,614	1,359	10	54
Japan	2,608	1,850	78	279	3	5
Mexico	28,504	13,795	29,637	11,400	44,290	17,090
Morocco	--	--	--	--	2,756	861
Netherlands	354	437	535	701	2,221	721
New Zealand	--	--	41	21	--	--
Peru	39,986	14,850	19,876	9,022	19,733	7,877
Singapore	59	19	--	--	--	--
South Africa, Republic of	--	--	--	--	84	20
South-West Africa, Territory of	--	--	1,120	549	--	--
Spain	--	--	119	162	93	217
Sweden	3	10	--	--	--	--
Thailand	144	655	437	1,609	408	1,447
United Kingdom	1,054	1,523	2,638	2,621	2,022	2,352
Yugoslavia	--	--	10,181	3,054	19,944	6,576
Other	35	37	12	39	3	2
Total	118,366	57,691	100,511	47,206	[3]145,932	[3]62,018
Reclaimed scrap, etc. (lead content):						
Australia	105	42	3,652	1,429	1,943	577
Bahamas	--	--	20	4	3	1
Canada	594	336	829	259	990	402
Canal Zone	7	16	--	--	--	--
Dominican Republic	11	5	--	--	--	--
Germany, West	--	--	58	41	70	31
Gilbert Islands	--	--	--	--	223	53
Jamaica	8	7	35	8	73	33
Mexico	271	85	735	224	156	56
Panama	11	3	--	--	--	--
Peru	--	--	--	--	901	360
United Kingdom	204	361	35	72	10	25
Other	2	1	1	3	44	12
Total	1,213	856	5,365	2,040	4,413	1,550
Grand total	214,709	92,118	193,898	76,574	229,044	90,085

[1]Data are "general imports" that is, they include lead imported for immediate consumption plus material entering the country under bond.
[2]Less than 1/2 unit.
[3]Adjusted by Bureau of Mines.

Table 28.—U.S. imports for consumption of lead, by country

Country	1974 Quantity (short tons)	1974 Value (thousands)	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Ore, flue dust, and residues, n.s.p.f. (lead content):						
Argentina	--	--	4	$1	--	--
Australia	15,156	$3,753	8,407	2,113	15,312	$4,390
Bolivia	9	9	--	--	--	--
Canada	11,998	2,712	14,878	3,521	8,556	2,471
Colombia	--	--	233	56	225	68
Honduras	15,536	3,536	7,438	2,330	25,624	10,704
Ireland	--	--	85	14	--	--
Mexico	6	1	--	--	8,661	3,290
Nicaragua	2,518	729	1,381	431	1,781	672
Peru	17,468	4,440	12,598	3,863	24,378	7,052
Other	--	--	--	--	4,451	845
Total	62,691	15,180	45,024	12,329	88,988	29,492
Base bullion (lead content):						
Belgium-Luxembourg	--	--	19	7	72	37
Canada	831	331	65	31	730	360
Mexico	--	--	378	145	1,532	558
Total	831	331	462	183	2,334	955
Pigs and bars (lead content):						
Australia	3,308	1,537	--	--	1,624	442
Belgium-Luxembourg	1,338	1,106	2,058	1,141	168	93
Canada	40,100	18,578	30,688	14,659	47,612	21,660
China, People's Republic of	--	--	28	111	--	--
Denmark	198	226	420	450	429	627
France	50	54	29	29	33	27
Germany, East	81	169	--	--	--	--
Germany, West	545	2,847	2,613	1,357	10	54
Japan	2,608	1,850	78	279	3	5
Mexico	28,504	13,795	28,728	11,073	44,290	17,090
Netherlands	354	437	535	701	2,221	721
New Zealand	--	--	41	21	--	--
Peru	39,986	14,850	19,876	9,022	19,733	7,877
Singapore	59	19	--	--	--	--
South Africa, Republic of	--	--	--	--	84	20
South-West Africa, Territory of	--	--	1,120	549	--	--
Spain	--	--	119	162	93	217
Sweden	3	10	--	--	--	--
Thailand	144	655	437	1,609	408	1,447
United Kingdom	1,054	1,523	2,638	2,621	2,022	2,352
Yugoslavia	--	--	9,634	2,880	20,491	6,749
Other	35	37	12	39	2,759	864
Total	118,367	57,693	99,054	46,703	141,980	60,245
Reclaimed scrap, etc. (lead content):						
Australia	--	--	16	6	--	--
Bahamas	--	--	20	4	3	1
Canada	755	368	921	280	990	402
Canal Zone	7	16	--	--	--	--
Dominican Republic	11	5	--	--	--	--
Germany, West	--	--	58	41	70	31
Gilbert Islands	--	--	--	--	223	53
Jamaica	8	7	35	8	73	33
Mexico	238	73	655	203	330	105
Panama	11	3	--	--	--	--
Peru	--	--	--	--	901	360
United Kingdom	204	361	35	72	10	25
Other	2	1	1	3	44	12
Total	1,236	834	1,741	617	2,644	1,022

See footnotes at end of table.

Table 28.—U.S. imports for consumption of lead, by country —Continued

Country	1974 Quantity (short tons)	1974 Value (thousands)	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Sheets, pipe, shot:						
Canada	110	71	52	54	113	130
Denmark	--	--	--	--	19	56
Germany, West	--	--	21	28	38	48
Japan	11	24	--	--	--	--
Mexico	71	39	72	12	20	10
Netherlands	(1)	1	--	--	--	--
Spain	--	--	--	--	65	205
United Kingdom	4	3	2	5	26	39
Other	(1)	(1)	--	--	13	7
Total	196	138	147	99	294	495
Grand total	183,321	74,176	146,428	59,931	236,240	92,209

[1]Less than 1/2 unit.

Table 29.—U.S. imports for consumption of lead, by class

(Thousand short tons and thousand dollars)

Year	Ore (lead content) Quantity	Ore (lead content) Value	Base bullion (lead content) Quantity	Base bullion (lead content) Value	Pigs and bars (lead content) Quantity	Pigs and bars (lead content) Value	Sheets, plates, strip, other forms Quantity	Sheets, plates, strip, other forms Value
1974	63	15,180	1	331	118	57,693	(1)	78
1975	45	12,329	(1)	183	99	46,703	(1)	91
1976	89	29,492	2	955	142	60,245	(1)	484

Year	Waste and scrap (lead content) Quantity	Waste and scrap (lead content) Value	Dross, skimmings, residues, n.s.p.f. (lead content) Quantity	Dross, skimmings, residues, n.s.p.f. (lead content) Value	Powder and flakes Quantity	Powder and flakes Value	Total value
1974	1	406	(1)	428	(1)	60	74,176
1975	1	411	(1)	206	(1)	8	59,931
1976	2	821	(1)	201	(1)	11	92,209

[1]Less than 1/2 unit.

Table 30.—U.S. imports for consumption of miscellaneous products containing lead[1]

Year	Gross weight (short tons)	Lead content (short tons)	Value (thousands)
1974	1,643	724	$8,730
1975	744	322	3,575
1976	452	175	1,749

[1]Babbitt metal, solder, white metal, and other lead-containing combinations.

Table 31.—Lead: World mine production, by country

(Short tons)

Country[1]	1974	1975	1976[p]
North America:			
Canada	[r]332,195	375,758	[e]283,000
Guatemala	110	110	110
Honduras	20,706	25,643	20,492
Mexico[2]	240,327	196,889	220,492
Nicaragua	3,746	1,565	1,403
United States[3]	663,870	621,464	609,546
South America:			
Argentina	[r]41,696	44,089	[e]44,100
Bolivia	[4]19,234	[4]15,755	18,043
Brazil	28,574	24,653	25,618
Chile	463	341	2,002
Colombia	139	126	[e]120
Equador	158	131	[e]120
Peru[5]	[r]182,761	203,486	186,591
Europe:			
Austria[3]	6,377	6,725	5,945
Bulgaria[e]	121,300	[r]121,300	119,000
Czechoslovakia[e]	4,300	[r]4,500	4,500
Finland	1,623	1,024	1,247
France	[r]25,414	23,920	31,000
Germany, East[e]	4,400	4,400	4,400
Germany, West	33,811	35,696	34,790
Greece	24,262	14,202	32,796
Greenland	[r]26,600	26,800	29,800
Hungary[e]	1,760	789	[e]790
Ireland[e]	41,560	40,010	35,100
Italy	[r]25,684	31,967	29,873
Norway	[r]3,721	3,559	4,303
Poland[e]	77,200	[r]82,200	87,100
Romania	[e]45,200	43,000	46,810
Spain	70,688	64,505	68,561
Sweden	81,192	77,584	88,200
U.S.S.R.[e]	[r]495,000	[r]495,000	520,000
United Kingdom[6]	4,000	3,902	2,530
Yugoslavia	132,085	139,879	[e]147,600
Africa:			
Algeria	3,420	3,200	4,000
Congo	[r]1,819	2,201	2,300
Kenya	[e]22	22	[e]22
Morocco	95,098	70,150	66,357
Nigeria[e]	240	[r]140	140
South Africa, Republic of	2,741	2,981	--
South-West Africa, Territory of[7]	62,568	56,514	[e]59,290
Tunisia	[r]13,783	11,842	11,424
Zambia (recoverable)	[r]27,100	21,400	16,300
Asia:			
Burma[e]	10,800	11,570	4,200
China, People's Republic of[e]	110,000	110,000	110,000
India	10,083	12,247	14,683
Iran	52,400	58,400	52,900
Japan[8]	48,775	55,739	56,952
Korea, North[e]	[r]130,000	[r]130,000	130,000
Korea, Republic of	11,573	13,409	16,020
Philippines	1,436	3,735	4,982
Thailand	1,701	1,690	996
Turkey	5,073	5,172	4,850
Oceania: Australia	413,701	448,826	439,344
Total	[r]3,762,489	3,750,210	3,700,742

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, Uganda and Egypt may produce lead, but available information is inadequate to make reliable estimates.

[2]Recoverable metal content of lead in concentrates for export plus lead content of domestic products (refined lead, antimonial lead, mixed bars, and other unspecified items).

[3]Recoverable metal.

[4]Production by COMIBOL plus exports by medium, small, and other mines.

[5]Recoverable metal; content of lead in concentrates for exports plus lead content of domestic smelter products (refined lead, antimonial lead, and bismuth-lead bars).

[6]May include small quantities of zinc.

[7]Data compiled from operating company reports of Tsumeb Corp. Ltd., South West Africa Co. Ltd., and South African Iron and Steel Industrial Corp. Ltd. (ISCOR) for Imcor Zinc (Pty.) Ltd.'s Rosh Pinah mine. Data from Tsumeb Corp. Ltd. are for calendar years; data from other companies are for fiscal years ending June 30 of the year stated.

[8]Content of concentrates.

Table 32.—Lead: World smelter production,[1] by country

(Short tons)

Country	1974	1975	1976[p]
North America:			
Canada (refined)	139,380	189,064	[e]193,000
Guatemala[2]	250	248	121
Mexico (refined)	220,660	190,620	209,142
United States (refined)[3]	673,024	636,122	652,906
South America:			
Argentina	38,600	43,700	44,100
Bolivia (refined, including solder)	23	--	--
Brazil	45,951	41,381	43,651
Peru (refined)	[r]88,799	78,544	81,731
Europe:			
Austria[4]	9,705	10,320	10,031
Belgium	[r]109,800	117,300	115,100
Bulgaria[e 2]	124,000	[r]124,000	121,000
Czechoslovakia[2]	19,698	20,334	[e]20,300
France[5]	174,794	149,233	175,714
Germany, East[e]	22,000	22,000	22,000
Germany, West	128,011	101,679	111,295
Greece (refined)[4]	16,100	18,000	20,604
Hungary[e 2]	14,880	[r]14,300	14,300
Italy	[r]50,753	36,593	50,093
Netherlands[2]	29,112	26,389	24,135
Poland (refined)[2]	78,900	84,000	88,800
Portugal (refined)	1,310	1,036	[e]1,000
Romania[e]	[r]45,200	43,000	46,300
Spain	87,666	80,853	83,244
Sweden (refined)	49,808	42,265	[e]38,400
U.S.S.R. (primary)[e]	525,000	530,000	550,000
United Kingdom[6]	32,386	28,328	18,190
Yugoslavia (refined)[2]	[r]125,472	139,000	122,599
Africa:			
Morocco	--	7,716	7,937
South-West Africa, Territory of (refined)	70,925	48,801	43,650
Tunisia	29,102	25,787	25,878
Zambia (refined)	27,112	21,054	15,002
Asia:			
Burma	10,246	10,974	3,672
China, People's Republic of[e]	110,000	110,000	110,000
India	4,394	5,257	5,991
Iran[e]	330	[r]330	440
Japan (refined)	251,283	214,087	241,464
Korea, North[e]	[r]90,000	[r]90,000	86,000
Korea, Republic of	[r]5,077	6,326	8,556
Thailand	1,346	1,041	[e]1,050
Turkey	6,170	3,300	2,600
Oceania: Australia (refined and bullion)	371,434	343,163	378,138
Total	[r]3,828,701	3,656,145	3,788,134

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Primary except as noted, or where source does not differentiate.
[2]Includes recovery from secondary materials.
[3]Refined from domestic and foreign ores; excludes lead from imported base bullion.
[4]Includes primary lead content of antimonial lead.
[5]Primary smelter lead plus lead content of all antimonial lead. (May include some secondary lead in antimonial lead.)
[6]Lead bullion from imported ores and concentrates.

Lime

By J. W. Pressler[1]

Lime output in 1976, including that for Puerto Rico, increased 6% to 20.3 million tons. Total value established a new annual record, increasing 16% to $612 million.

Output of most types of lime increased. Agricultural lime was up 40%, refractory dolomite 10%, and chemical and industrial lime 6%; construction lime remained the same.

Table 1.—Salient lime statistics in the United States[1]

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
Number of plants	185	175	172	171	163
Sold or used by producers:					
Quicklime	16,611	17,230	17,795	15,875	16,924
Hydrated lime	2,604	2,610	2,533	2,344	2,298
Dead-burned dolomite	1,075	1,250	1,278	914	1,007
Total	20,290	21,090	21,606	19,133	20,229
Value[2]	$339,304	$365,849	$473,685	$523,805	$609,010
Average value per ton	$16.72	$17.35	$21.92	$27.38	$30.11
Lime sold	13,353	14,394	14,640	12,840	14,024
Lime used	6,937	6,696	6,966	6,292	6,205
Exports[3]	38	37	32	54	56
Imports for consumption[3]	248	334	416	259	365

[1]Excludes regenerated lime. Excludes Puerto Rico.
[2]Selling value, f.o.b. plant, excluding cost of containers.
[3]Bureau of the Census.

DOMESTIC PRODUCTION

Lime producers sold or used 20.3 million tons, compared with 19.2 million tons in 1975. Sales of lime increased 9% to 14.1 million tons. Captive lime used by producers declined 1% to 6.2 million tons.

Output of quicklime increased 7% to 17.9 million tons. Production of hydrated lime decreased 2% to 2.3 million tons. Output of dead-burned dolomite increased 10% but was 58% below the 1956 record high level.

Six States—Ohio, Pennsylvania, Missouri, Michigan, Texas, and Alabama—accounted for 57% of the total output. Production increased 9% in Ohio, 8% in Missouri, 7% in Pennsylvania, and 2% in Michigan and Alabama, but decreased 16% in Texas.

Leading producing companies were Marblehead Lime Co. with two plants in Illinois and one each in Indiana, Michigan, Pennsylvania, and Utah; Mississippi Lime Co. in Missouri; Bethlehem Steel Corp. with two plants in Pennsylvania and one in New York; Martin Marietta Corp.'s Chemical Div. in Alabama and Ohio; Allied Chemical Corp. in New York; The Flintkote Co. with two plants in California, two in Nevada, and one each in Arizona, Utah, and Virginia; Allied Products Co. with two plants in Alabama; Pfizer, Inc. in California, Connecticut, Massachusetts, and Ohio; United States Gypsum Co. in Louisiana, Ohio, and

[1]Physical scientist, Division of Nonmetallic Minerals.

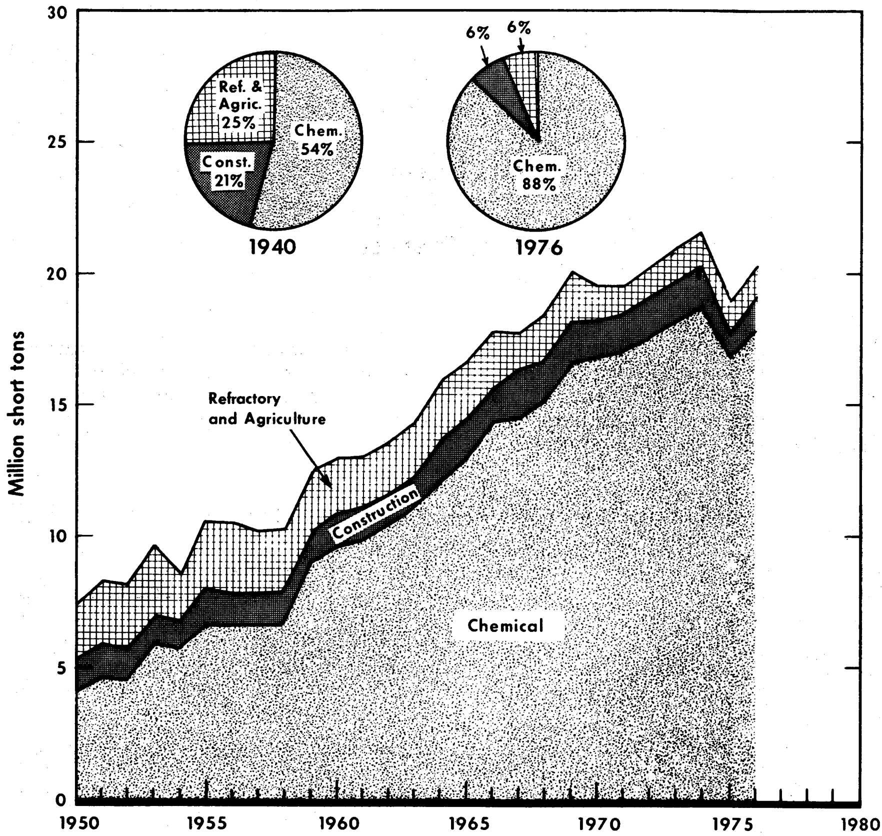

Figure 1.—Trends in major uses of lime.

Texas; and Diamond Shamrock Corp. in Ohio. These 10 companies, operating 30 plants, accounted for 43% of the total lime production.

The eight largest lime plants, each producing more than 400,000 tons, accounted for 26% of the total lime output. Thirty-four plants produced more than 200,000 tons and accounted for 64% of the total.

Leading individual plants were Mississippi Lime's Ste. Genevieve plant, Marblehead's Buffington plant, Allied Chemical's Syracuse plant, Martin Marietta's Woodville plant, and Bethlehem's Annville plant.

A total of 532 kilns were operational during the year: 310 vertical kilns; 170 rotary kilns; 25 pot kilns (primitive vertical); 15 "Calcimatic" traveling hearth kilns; 6 fluidized bed kilns; 4 "Ellernan" kilns; and 2 traveling-grate rotary kilns.

In 1976, the number of lime plants in the United States decreased from 172 to 164, but the average output per plant increased from 111,400 to 123,500 tons per year. Nine lime plants were closed and reported no production in 1976: The Carley L. Moore plant in Globe, Ariz.; the Great Western Sugar Co. plant in Eaton, Colo.; the Olin Corp. plant in Lake Charles, La.; the Allied Chemical Corp. plant in Baton Rouge, La.; the Pacific Carbide & Alloys Co. plant in Portland, Oreg.; the Tennessee Lime Co. plant in Knoxville, Tenn.; the Round Rock Lime Co. plant in Dolomite (Williamson County), Tex.; the Mountain States Lime, Inc., plant in Provo, Utah; and the Jones & Laughlin Steel Corp. plant in Martinsburg, W. Va. One rehabilitated plant started up in 1976—Limestone Products Corp.'s Limecrest plant in Sussex County, N.J.

Table 2.—Lime sold or used by producers in the United States, by State and kind[1]

(Thousand short tons and thousand dollars)

State	1975					1976				
	Plants	Hydrated	Quicklime	Total[2]	Value	Plants	Hydrated	Quicklime	Total[2]	Value
Alabama	5	128	857	985	29,404	5	149	860	1,009	32,753
Arizona	7	W	W	512	12,444	6	W	W	546	16,115
Arkansas	3	W	W	170	3,848	3	W	W	182	4,900
California	15	57	538	595	18,626	15	47	591	638	23,324
Colorado	11	W	W	198	4,577	10	W	W	185	4,406
Connecticut	1	14	9	23	1,013	1	12	12	24	1,103
Florida	3	W	W	199	7,708	3	W	W	179	7,798
Hawaii	2	W	W	6	250	2	W	W	W	W
Louisiana	4	W	W	485	12,484	2	W	W	W	W
Maryland	1	5	10	15	434	1	5	11	16	494
Massachusetts	2	20	132	152	5,215	2	16	162	178	6,354
Michigan	9	--	1,434	1,434	36,540	9	--	1,456	1,456	39,686
Minnesota	4	--	W	W	W	4	--	103	103	2,794
Mississippi	1	--	53	53	1,060	1	--	57	57	1,248
Missouri	3	W	W	1,606	40,630	3	W	W	1,731	49,907
Montana	3	--	221	221	5,188	3	--	224	224	5,980
Ohio	17	177	3,305	3,482	95,136	17	169	3,619	3,788	114,299
Oregon	3	W	W	96	3,281	2	W	W	W	W
Pennsylvania	10	336	1,605	1,940	60,047	10	340	1,729	2,069	68,356
Puerto Rico	1	27	1	28	2,231	1	28	(3)	28	2,513
Tennessee	3	W	W	106	3,735	2	W	W	W	W
Texas	13	695	1,040	1,735	46,179	12	605	850	1,455	43,983
Utah	5	W	W	161	4,540	4	W	W	202	6,855
Virginia	6	38	667	705	20,192	5	53	824	878	25,993
Wisconsin	5	109	187	296	8,604	5	120	206	325	10,058
Other States[4]	35	765	6,730	3,957	102,670	35	781	7,226	4,981	142,605
Total[2]	172	2,371	16,789	19,159	526,036	164	2,326	17,930	20,257	611,523

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Includes data for 35 lime plants, as follows: 4 each in Idaho and Nebraska; 3 each in Illinois, Nevada, Washington, and Wyoming; 2 each in Indiana, New York, New Mexico, and North Dakota; West Virginia (2 in 1975 and 1 in 1976); 1 each in Iowa, Kansas, Kentucky, Oklahoma, and South Dakota; and New Jersey (1 in 1976). Also includes States indicated by symbol W and exports.

Riverton Corp., headquartered at Riverton, Va., acquired the assets of Jones & Laughlin Steel Corp.'s Blair Division. Located at Riverton, W. Va., the Blair facilities manufactured lime, limestone products, construction aggregates, and ballast. The 108-year-old Riverton firm was a pioneer in developing colored cements. Its rapidly expanding stone division now produces from five quarries.[2]

New plants and expansions.—Western Lime & Cement Co. purchased a 10- by 150-foot rotary kiln and ancillary equipment from Louisville Cement Co. and installed it in its Green Bay, Wis., lime plant. The gas-, oil-, or coal-fired kiln with preheater had a 200-ton-per-day lime capacity and doubled the plant capacity to 400 tons per day.

Dravo Corp.'s new $60 million underground limestone mine and three 1,000-ton-per-day preheater lime kilns at Maysville, Ky., went into test operation and debugging in late 1976. At yearend, its "Thiosorbic" specialty lime output was already 75% sold to utilities in Pennsylvania and Ohio under long-term contracts for use as scrubber lime.

The Flintkote Co.'s U.S. Lime Division in Nelson, Ariz., placed into production in 1974 its new 800-ton-per-day preheater lime plant. Construction was initiated in 1976 for a second, larger lime kiln with a production capacity of 1,000 tons per day, reportedly to be operational by mid-1978.

Black River Mining Co., located at Carntown, Ky., a joint venture of Armco Steel Corp. and Jones & Laughlin Steel Corp., placed into operation in mid-1976 a third lime kiln, doubling the plant's production capacity to 2,000 tons per day. The new Allis-Chalmers 13-1/2- by 14-1/2- by 400-foot rotary kiln reportedly is the largest rotary lime kiln in the United States.

The S. I. Lime Co., a subsidiary of Southern Industries Corp., installed a third kiln at its Saginaw plant near Birmingham, Ala., doubling its capacity to 1,000 tons per day. A lime distribution terminal was also opened at Tampa, Fla.

Chemical Lime, Inc., initiated construction at midyear for the installation of a 10-1/2- by 340-foot Allis-Chalmers rotary kiln and auxiliary equipment. Production will be increased from the present 350 tons per day to 750 tons per day. The kiln will burn a blend of Texas lignite coal and natural gas and will be operational at yearend 1978.

Energy.—The lime industry in 1976 made some progress in its utilization of energy with the addition of preheaters to kilns and by improvements in internal agitation in the kilns; these changes resulted in a 3.3% improvement in energy consumption compared with the base year of 1972. British thermal unit (Btu) consumption per ton of lime produced in 1976 was 7.79 million, compared with 8.06 million in 1975.

As reported by the National Lime Association, the fuel sources for the lime industry in 1976 were as follows: Coal and coke, 50.7%; natural gas, 40.7%; oil (No. 2 and No. 6), 7.0%; and electricity, 1.6%. Compared with the base year of 1972, significant improvements were made in 1976 with a 24% reduction in the use of scarce natural gas and an 80% increase in the use of coal and coke.[3]

[2]Rock Products. V. 79, No. 9, September 1976, p. 17.
[3]U.S. Department of Commerce and Federal Energy Administration. Voluntary Industrial Energy Conservation. Progress Report 5, July 1977, pp. 102-103.

Table 3.—Lime sold or used by producers in the United States, by size of plant[1]

(Thousand short tons)

Size of plant	1975			1976		
	Plants	Quantity	Percent of total	Plants	Quantity	Percent of total
Less than 10,000 tons	29	187	1	24	128	1
10,000 to 25,000 tons	31	556	3	27	464	2
25,000 to 50,000 tons	23	749	4	27	954	5
50,000 to 100,000 tons	28	1,968	10	26	1,835	9
100,000 to 200,000 tons	28	4,136	22	26	3,982	20
200,000 to 400,000 tons	28	8,024	42	26	7,576	37
More than 400,000 tons	5	3,540	18	8	5,319	26
Total	172	[2]19,159	100	164	[2]20,257	100

[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Data do not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Lime was consumed in every State. Leading consuming States were Ohio, Pennsylvania, Michigan, Indiana, Texas, New York, and Illinois, each of which consumed more than 1 million tons. These seven States accounted for 62% of the total lime consumed.

Leading quicklime-consuming States were Ohio, Pennsylvania, Michigan, Indiana, and New York, each of which consumed more than 1 million tons. These five States accounted for 53% of the total quicklime consumed.

Leading hydrate-consuming States were Texas, Pennsylvania, Louisiana, Ohio, and Illinois, each of which consumed more than 100,000 tons. These five States accounted for 53% of the total hydrate consumed.

Lime sold by producers was used for chemicals, 88%; construction, 6%; refractories, 5%; and agriculture, 1%. Captive lime used by producers was 31% of the total, compared with 33% in 1975. Captive lime was used mainly for alkalies, 33%; basic oxygen steel furnaces (BOF's), 26%; and sugar refining, 15%.

Leading individual uses were BOF's, alkalies, water purification, paper and pulp, refractories, and sugar refining, which together accounted for 69% of the total consumption.

Of the main chemical and industrial uses, lime for BOF's was produced principally in Ohio (26%), Indiana (15%), Pennsylvania (14%), and Illinois (10%). Lime for alkalies was produced mainly in Michigan, New York, Ohio, and Texas. Lime for water purification was produced mainly in Missouri (28%), Pennsylvania (17%), Texas (7%), and Alabama (7%). Lime used for paper and pulp, excluding regenerated lime, was produced mainly in Alabama (30%), Texas (14%), Wisconsin (10%), and Tennessee (5%). Lime for refining sugar was produced mainly in California (23%), Idaho (12%), and Colorado (9%).

Mason's lime was produced in 35 plants in 17 States, including Puerto Rico. Some of the leading States were Wisconsin with five plants (20%), Pennsylvania with four plants (18%), and Ohio with four plants (10%). Finishing lime was produced in 12 States in 17 plants, including Puerto Rico. The leading State was Ohio with four plants (60%).

The use of lime in agriculture has decreased from 250,000 tons per year in 1956 to 140,000 tons per year in 1976, indicating a negative annual growth rate of about 4.5%. The high cost of energy-intensive lime, compared with that of pulverized limestone for controlling the adverse acid condition of soil, and the attainment of maximum fertilizer utilization have diverted farmers to the use of the cheaper commodity, even though its reactivity response is considerably less. During the same period, the use of crushed and pulverized limestone in agriculture has increased from 20 million tons per year in 1956 to about 39 million tons per year in 1976, a growth rate of 2.0% per year.

The growth rate of 2.0% in the use of agricultural limestone is similar to that of total plant nutrients in fertilizers used, and also to the growth in the harvested crop acreage. Inadequate lime usage in agriculture is one of the most important factors limiting more efficient crop production throughout much of the country. Undoubtedly, a major reason why farmers fall so far short of using the needed lime is the nature of the crop response obtained. Whereas crop response to fertilizers is rapid, the response to lime applications is much slower. It is frequently unnoticed until at least 1 year after application, especially when pulverized limestone is used. Although the effects of a single application of lime may last several years, many farmers do not recognize this and are not willing to wait for the returns on their investments.[4]

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[4]Hargett, N. L. Fertilizer Data Summary. National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Ala. Bull. Y-112, 1976, pp. 6-7.
American Potash Institute. Potash Newsletter for Eastern Territory. No. 105, September 1958, p. 2.

Table 4.—Destination of shipments of lime sold or used by producers in the United States in 1976, by State[1]

(Short tons)

State	Quicklime	Hydrated lime	Total
Alabama	487,573	64,077	551,650
Arizona	483,177	14,012	497,189
Arkansas	165,674	24,958	190,632
California	777,132	84,747	861,879
Colorado	278,953	17,361	296,314
Connecticut	44,113	10,910	55,023
Delaware	16,965	5,771	22,736
District of Columbia	--	519	519
Florida	309,939	46,885	356,824
Georgia	168,561	27,021	195,582
Hawaii	2,868	5,504	8,372
Idaho	137,077	6,818	143,895
Illinois	898,619	108,912	1,007,531
Indiana	1,916,747	70,161	1,986,908
Iowa	69,913	19,828	89,741
Kansas	76,944	21,019	97,963
Kentucky	369,031	16,694	385,725
Louisiana	156,958	115,834	272,792
Maine	22,703	2,205	24,908
Maryland	457,649	18,379	476,028
Massachusetts	42,233	11,589	53,822
Michigan	1,951,366	46,783	1,998,149
Minnesota	180,762	17,371	198,133
Mississippi	123,155	25,095	148,250
Missouri	163,280	39,737	203,017
Montana	224,958	3,584	228,542
Nebraska	57,957	8,858	66,815
Nevada	16,200	10,025	26,225
New Hampshire	7,613	671	8,284
New Jersey	67,618	54,971	122,589
New Mexico	94,778	12,360	107,138
New York	1,000,552	36,112	1,036,664
North Carolina	136,875	29,996	166,871
North Dakota	50,704	6,858	57,562
Ohio	2,701,434	112,351	2,813,785
Oklahoma	76,980	23,134	100,114
Oregon	97,744	14,213	111,957
Pennsylvania	2,013,900	267,680	2,281,580
Puerto Rico	W	W	27,069
Rhode Island	W	W	8,605
South Carolina	81,304	12,364	93,668
South Dakota	27,883	17,965	45,848
Tennessee	128,046	68,729	196,775
Texas	856,257	627,908	1,484,165
Utah	100,505	20,003	120,508
Virginia	160,442	29,121	189,563
Washington	160,529	20,288	180,817
West Virginia	387,414	20,314	407,728
Wisconsin	114,571	51,017	165,588
Wyoming	34,350	8,102	42,452
Other States[2]	7,719	33,092	5,137
Total United States	17,907,725	2,311,906	20,219,631
Exports:			
Canada	10,057	14,094	24,151
Other countries	13,059	204	13,263
Total exports	23,116	14,298	37,414
Grand total	17,930,841	2,326,204	20,257,045

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Includes Alaska, Vermont, and the Virgin Islands; and States indicated by symbol W.

Table 5.—Lime sold or used by producers in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1975 Sold	1975 Used	1975 Total[2]	1975 Value	1976 Sold	1976 Used	1976 Total[2]	1976 Value
Agriculture	97	--	97	3,371	136	--	136	4,759
Construction:								
Soil stabilization	749	1	750	21,165	742	(3)	743	24,597
Mason's lime	282	1	283	7,970	351	1	351	11,616
Finishing lime	196	--	196	5,520	132	--	132	4,363
Other construction uses	28	34	61	1,720	35	35	70	2,310
Total[2]	1,255	36	1,291	36,375	1,260	35	1,295	42,886
Chemical and industrial:								
Steel, BOF	5,024	1,518	6,542	177,000	5,800	1,618	7,418	219,306
Alkalies	7	2,093	2,100	56,700	7	2,072	2,078	61,434
Water purification	1,394	9	1,403	37,900	1,515	8	1,523	45,026
Paper and pulp	819	102	921	24,900	946	108	1,054	31,160
Sugar refining	77	837	914	24,700	76	909	985	29,121
Steel, electric	583	79	663	17,900	707	71	778	23,001
Copper ore concentration	327	356	683	18,400	386	284	670	19,808
Sewage treatment	611	70	681	18,400	548	90	638	18,862
Steel, open-hearth	467	44	511	13,800	340	83	423	12,506
Aluminum and bauxite	140	154	294	7,940	143	152	296	8,751
Magnesia from seawater	W	W	W	W	W	W	237	7,007
Calcium carbide	113	92	205	5,530	156	77	232	6,859
Glass	261	--	261	7,050	213	--	213	6,297
Precipitated calcium carbonate	40	25	65	1,750	44	36	81	2,395
Petrochemicals	64	--	64	1,730	72	--	72	2,129
Acid mine water	49	1	50	1,350	57	(3)	58	1,715
Food products	29	34	63	1,700	21	35	56	1,656
Metallurgy, other	52	2	53	1,430	51	--	51	1,508
Oil well drilling	41	--	41	1,110	47	--	47	1,390
Petroleum refining	30	--	30	810	42	--	42	1,242
Sulfur removal	3	--	3	80	30	--	30	887
Magnesium metal	8	13	21	567	W	W	27	798
Tanning	26	--	26	702	25	--	25	739
Fertilizer	7	--	7	190	12	--	12	355
Insecticides	10	--	10	270	9	--	9	266
Paint	4	--	4	108	4	--	4	118
Rubber	3	--	3	80	4	--	4	118
Ore concentration, other	7	--	7	190	3	--	3	89
Wire drawing	1	1	2	50	2	(3)	2	59
Plastics	25	--	25	675	W	--	W	W
Other uses[4]	444	762	1,206	32,086	457	559	751	22,199
Total	10,666	6,192	16,858	455,098	11,717	6,102	17,819	526,801
Refractory dolomite	849	64	914	31,193	938	68	1,007	37,079
Grand total[2]	12,868	6,292	19,159	526,036	14,052	6,205	20,257	611,523

W Withheld to avoid disclosing individual company confidential data; included in "Other uses."
[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Includes sand-lime brick, silica brick, magnesite, chrome, lithium, explosives, adhesives, coke (1975), other uses, and uses indicated by symbol W.

PRICES

The average value of lime sold or used by producers in 1976 was $30.19 per ton, an increase of 10% over the 1975 price of $27.46 and an increase of 73% over the 1973 price of $17.42.

Values ranged from $29.56 for chemical and industrial lime to $33.12 for construction lime, $36.82 for refractory dolomite, and $34.99 for lime used in agriculture.

Values for quicklime sold ranged from $29.14 for chemical lime to $33.53 for construction lime, $33.52 for lime used in agriculture, and $36.85 for dead-burned dolomite, and averaged $29.82, an increase of 6% over the 1975 value.

Values for hydrated lime ranged from $33.13 for construction lime to $34.84 for chemical lime and $36.53 for lime used in agriculture, and averaged $34.02, an increase of 15% over the 1975 price.

FOREIGN TRADE

Exports of lime increased 4% to 55,900 tons but were 19% below the 1968 record. Of the total exports, Canada received 87%, and Mexico and Panama received 3% each. The remaining 7% went to 36 countries, listed in order of shipments as follows: Guyana, United Arab Emirates, Bahamas, Bermuda, El Salvador, New Zealand, Philippines, Honduras, the United Kingdom, Venezuela, Saudi Arabia, Bahrain, Spain, Egypt, West Germany, Surinam, Australia, Brazil, Gabon, Colombia, Argentina, the Pacific Trust Islands, Netherlands Antilles, Peru, Jamaica, Japan, Iraq, the French Pacific Islands, Belize, Haiti, the Netherlands, Nicaragua, Guatemala, Iran, the Republic of South Africa, and Italy.

Imports of lime increased 41% to 364,900 tons. Imports were mainly from Canada.

Table 6.—U.S. exports of lime

Year	Quantity (short tons)	Value (thousands)
1974	31,639	$1,516
1975	53,853	2,746
1976	55,852	2,981

Table 7.—U.S. imports for consumption of lime

	Hydrated lime		Other lime		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	48,284	$1,311	367,917	$6,368	416,201	$7,679
1975	44,637	1,392	214,311	4,867	258,948	6,259
1976	48,461	1,814	316,442	8,816	364,903	10,630

WORLD REVIEW

Lime is produced all over the world, mainly in the heavily industrialized nations. Source materials are adequate. The United States, with 17% of the total, ranks second in world production.

Canada.—During 1976, 18 companies operated 24 lime plants in Canada: 10 in Ontario, 4 in Quebec, 4 in Alberta, 3 in Manitoba, 2 in British Columbia, and 1 in New Brunswick. Of the 85 kilns in operation, 54 were vertical, 27 were rotary, 3 were rotary grate, and 1 was vibratory grate. Total lime output was 2.0 million tons, of which 341,000 tons, with a customs-declared value of $29.42 per ton, was exported to the United States.

China, People's Republic of.—Imperial Krauss Maffei Industrieanlagen GmbH (Munich, West Germany) will supply a lime plant to the People's Republic of China. The 600-ton-per-day facility, to be erected near Wuhan, will produce a highly reactive lime for the Chinese steel industry.[5]

[5]Chemical Engineering. V. 84, No. 5, Feb. 28, 1977, p. 222.

Table 8.—Quicklime and hydrated lime, including dead-burned dolomite: World production by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
North America:			
Canada	2,009	1,765	2,012
Costa Rica	24	17	[e]17
Guatemala	62	39	50
Jamaica	[r]336	202	269
Nicaragua[e]	43	51	51
Puerto Rico	39	28	28
United States (sold or used by producers)	21,606	19,133	20,229
South America:			
Brazil[e]	2,200	2,200	2,200
Chile[e]	[r]660	[r]660	660
Colombia[e]	1,100	1,100	1,100
Paraguay	30	31	35
Peru[e]	[r] (2)	(2)	(2)
Uruguay	51	51	77
Europe:			
Austria	1,145	826	1,057
Belgium	[r]3,558	2,778	2,540
Bulgaria	1,446	1,753	[e]1,800
Czechoslovakia	3,073	3,262	3,300
Denmark	188	183	255
Finland[e]	[r]316	[r]298	285
France	5,625	4,842	5,265
Germany, East	3,337	3,340	[e]3,300
Germany, West	12,358	10,114	10,608
Hungary	701	787	808
Ireland	87	86	[e]88
Italy	[3]2,557	1,952	2,122
Malta	[r e]11	9	[e]9
Norway	127	133	[e]132
Poland[4]	8,772	9,059	8,940
Portugal	238	235	[e]220
Romania	[r]3,385	3,377	[e]3,300
Spain	438	[r e]440	[e]440
Sweden (sales)	977	869	[e]860
Switzerland	125	80	78
U.S.S.R.[e]	24,000	[r]25,000	25,000
Yugoslavia	2,248	2,296	[e]2,100
Africa:			
Algeria[e]	[r]44	[r]44	44
Burundi	(2)	(2)	1
Egypt[e]	90	90	90
Ethiopia	6	(5)	--
Kenya	(5)	217	220
Libya	22	15	358
Mauritius	4	8	8
Malawi[e]	(2)	(2)	(2)
Mozambique	[r]930	591	[r]550
South Africa, Republic of (sales)	1,322	1,464	1,529
Tanzania	6	8	[e]11
Tunisia	126	312	351
Uganda[e]	33	33	33
Zaire[e]	165	165	165
Zambia	[e]120	[r e]130	159
Asia:			
Cyprus	67	25	12
India[e]	375	375	375
Iran[e]	1,100	1,100	1,100
Israel	220	265	220
Japan	12,362	10,110	10,115
Jordan	3	3	3
Korea, Republic of[e]	105	110	120
Kuwait	(2)	(2)	(2)
Lebanon	195	[e]200	[e]200
Mongolia[e]	45	45	45
Nepal	(2)	60	[e]66
Philippines	111	40	30
Saudi Arabia[e]	17	17	17
Taiwan	171	161	181
Oceania:			
Australia[6]	1,038	[r e]1,050	[e]1,050
Fiji Islands	3	3	3
Total	[r]121,542	[r]113,637	116,291

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Lime is produced in many other countries besides those listed. Mexico, Venezuela and the United Kingdom are among the more important countries for which official data are unavailable.
[2]Less than 1/2 unit.
[3]Hydraulic lime.
[4]Excludes output by small producers.
[5]Revised to zero.
[6]Year ending June 30 of that stated.

Germany, West.—Brisk demand in 1976 for one-family and multifamily houses led to a 16% increase in sales of lime in West Germany.[6]

New Zealand.—In spite of reduced demand for cement in 1976, New Zealand Cement Holdings Ltd. reported increased sales of lime, mainly owing to an increase in agricultural lime demand, with an expansion to 134,000 tons in 1976 compared with 97,000 tons in 1975.[7]

Qatar.—Newell Dunford Engineering (London, England) was awarded a $4 million contract to supply a complete lime calcination plant to Qatar. The plant will be built at Umm Bab for the Qatar National Cement Co.[8]

South Africa, Republic of.—Union Lime Co. Ltd. of Ulco commissioned a lime plant in April 1976 at Danielskuil, Ouplaas Farm. F. L. Smidth & Co., Ltd. supplied two 12-1/2- by 466-foot rotary kilns. The cost of the total project—quarry, crushing plant, two kiln plants, unloading plant, and infrastructure—will amount to $28 million. The new plant had a capacity of 1,400 tons per day and, combined with the original 11-vertical-kiln plant, increased the company's quicklime capacity to 840,000 tons per year. Union Lime now has a 35% share of the total South African burned-lime market.[9]

Switzerland.—Although the market for hydraulic lime in Switzerland showed a slight overall decline, Cement- und Kalkfabrik Unterterzen AG reportedly increased sales 12% to 10,100 tons by the takeover of deliveries from Cement- und Kalkwerk Liesberg AG's lime plant, which had suspended production.[10] At the Cementfabrik Holderbank plant in Holderbank, the Lime Division increased its sales of hydraulic lime 16% to 14,400 tons.[11]

United Arab Emirates.—Holderbank Management and Consulting Ltd., Engineering Division, reportedly received a contract for a new lime plant at Al-Ain in the Emirate of Abu Dhabi.[12]

TECHNOLOGY

The installation of preheaters on two 11- by 10- by 314-foot rotary lime kilns lowered fuel consumption and increased production at the Woodville, Ohio, plant of Martin Marietta Corp. An overall fuel saving of 1.5 million Btu per ton of lime produced and an increased production of 98,000 tons per year of lime from the two kilns were realized.[13]

Although a preheater lime kiln gives excellent fuel economy and greater throughput, a long rotary kiln without preheater is sometimes preferable because it produces a lower sulfur product, can handle smaller stone sizes, can treat stone that becomes soft when semicalcined, and is simpler to operate than a preheater. If a long lime kiln is fitted with all of the heat-exchanging internal equipment possible, it can still achieve excellent fuel economy, and the extra capital cost can be justified by the money saved in fuel.[14]

Excessive particulates emitted from most lime-producing kilns require expensive dry collection systems, as well as efficient wet scrubbing systems. Corrosion of parts and material buildup with subsequent loss of production can result unless operating variables are closely controlled. High water-to-gas ratios, saturation of inlet gas, neutralization of recycled slurry water and of pipeline slurries, and an extended humidification zone in the gaseous phase of the wet scrubber unit are all important requirements.[15]

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[6]Holderbank Financiere Glaris Ltd. (Zurich, Switzerland). Annual Report 1976, p. 16.
[7]Page 35 of work cited in footnote 6.
[8]Financial Times (London, England). Nov. 23, 1976.
[9]Ritchie, D. Union Lime Co.'s Ouplaas Works. Rock Products, v. 80, No. 6, June 1977, pp. 48-51, 84, 88.
Page 3 of work cited in footnote 6.
[10]Page 12 of work cited in footnote 6.
[11]Page 11 of work cited in footnote 6.
[12]Page 11 of work cited in footnote 6.
[13]Robertson, J. L. Preheaters Equal Lower Fuel Costs, High Production. Rock Products, v.79, No. 6, June 1976, pp. 55-59.
[14]Kramm, D. J. Save Fuel With Heat Exchanging Internals. Pit and Quarry, v. 69, No. 11, May 1977, pp. 65-67.
[15]Abos, R. L., and M. D. Challis. Scrubbers for Lime Kiln Exhausts. Rock Products, v. 79, No. 6, June 1976, pp. 85-86.

Lithium

By C. K. Quan[1]

Although domestic production of lithium minerals and compounds showed a minimal growth in 1976, consumption rose about 9% over that of 1975. The United States continued as the world's leading producer, supplying about 79% of total demand. Other primary producers of lithium materials included the U.S.S.R., Brazil, South-West Africa, and Southern Rhodesia. West Germany, although not a primary producer, was an important supplier of lithium products manufactured from imported lithium carbonate and lithium hydroxide.

The largest end use of lithium was as lithium carbonate in aluminum potlines, where it increases capacity, lowers energy requirements, and reduces fluoride emissions. It is estimated that aluminum production accounted for 50% of total domestic consumption of lithium and 38% of world consumption in 1976. Other major applications of lithium were in glass and ceramics and in lubrication, together accounting for 40% of domestic demand and 43% of world demand. Continued growth of lithium consumption in these major end uses is expected.

A highlight of the lithium industry consisted of the startup, at yearend, of a 12-million-pound-per-year lithium carbonate plant at Kings Mountain, N.C. The new facility of Foote Mineral Co. represented a 20% increase in lithium production capacity of market economy countries.

Legislation and Government Programs.— Imports of lithium materials are subject to the following tariff structure:

Tariff class	TSUS No.	Rate of duty	Statutory rate
Lithium mineral concentrates	423.81	None	None
Lithium metal	415.30	12.5% ad valorem	25% ad valorem
Lithium compounds	419.10	5% ad Valorem	25% ad valorem

A 22% depletion allowance against Federal income tax is granted on the mining of domestic reserves, compared with 14% for foreign reserves.

The General Services Administration (GSA) continued selling surplus lithium hydroxide monohydrate, depleted of its Li-6 isotope, to domestic and foreign consumers. During 1976 about 1.98 million pounds were disposed of, for a total value of $1.52 million. At yearend total disposable inventory was reported at 3.11 million pounds valued at $4.18 million. However, an additional 80 million pounds of surplus material have since become available from Energy Research and Development Administration (ERDA) stockpiles.[2] It is understood that Lithium Corp. of America (Lithcoa) and Foote Mineral Co. are considering long-term commitments to purchase 20 million pounds each, under the proviso that the material be used in the production of lithium carbonate or lithium carbonate-based products. Twenty-eight million pounds are being offered for sale to any other firm (or firms) that desires to participate in the disposal program, provided that it has the financial and technological capability of becoming a domestic primary lithium producer or producer of lithium carbonate or

[1]Physical scientist, Division of Nonmetallic Minerals.
[2]GSA stockpile information, No. P-2164, Jan. 7, 1977.

lithium carbonate- based products. The remaining 12 million pounds of surplus material have been set aside for sale under sealed bid on an unrestricted-use basis to any firm other than Lithcoa and Foote Mineral.

Table 1.—GSA stockpile and sales of lithium hydroxide monohydrate

Date	Total Inventory[1]		Sales[2]	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Jan. 31, 1976	5,094,104	6,129	--	--
Feb. 29, 1976	5,094,104	6,129	--	--
Mar. 31, 1976	5,014,104	6,047	80,000	82
Apr. 30, 1976	5,014,104	6,047	--	--
May 31, 1976	5,014,104	6,047	--	--
June 30, 1976	4,453,679	5,653	560,425	394
July 31, 1976	3,953,679	5,163	500,000	490
Aug. 31, 1976	3,553,679	4,893	400,000	270
Sept. 30, 1976	3,510,235	4,458	43,444	6
Oct. 31, 1976	3,110,235	4,178	400,000	280
Nov. 30, 1976	3,110,235	4,178	--	--
Dec. 31, 1976	3,110,235	4,178	--	--
Total sales	XX	XX	1,983,869	1,522

XX Not applicable.
[1]Inventory as of month end.
[2]Total sales during month.

Source: General Services Administration.

DOMESTIC PRODUCTION

To avoid disclosure of individual company confidential data, the Bureau of Mines continued its policy of withholding from publication statistics on domestic production that it obtained from official canvasses. However, in response to a growing need by the public, data currently available in other published sources will be presented.

Table 2 summarizes estimates of domestic production for the years 1971-76, as published by the Canadian Department of Energy, Mines and Resources and by Gulf Resources and Chemical Corp. of which Lithcoa is a wholly owned subsidiary.

Canadian data, traditionally reported in terms of lithia (Li_2O) content, have been converted to a lithium carbonate (Li_2CO_3) equivalent basis by a multiplicative factor of 0.464. Consistently, Canadian estimates of total U.S. production have been higher than Lithcoa's estimates. It is believed, however, that Canadian data represent upstream production of mineral concentrates and lithium carbonate, while Lithcoa's data are based on total downstream production of a variety of lithium products.

As in previous years, Lithcoa, Foote Mineral Co. and Kerr-McGee Corp. accounted for the entire domestic production, with an estimated total annual capacity of some 28,500 tons of lithium carbonate equivalent at yearend 1976.

Table 2.—Domestic production of lithium

(Short tons of Li_2CO_3 equivalent)

	Total Domestic Production		Lithcoa production[2]
	Canadian estimate[1]	Lithcoa estimate[2]	
1971	17,311	15,250	7,831
1972	19,289	16,350	10,792
1973	26,461	18,000	12,046
1974	29,429	19,450	12,840
1975	26,461	20,000	12,127
1976	NA	20,500	12,820

NA Not available.
[1]G.H.K. Pearse, Canadian Minerals Yearbooks.
[2]Gulf Resources and Chemical Corporation Annual Reports.

Table 3.—Domestic producers of lithium

Company	Plant location	Estimated capacity (short tons Li_2CO_3 equivalent per year)
Lithium Corp. of America	Bessemer City, N.C	13,500
Foote Mineral Co	Silver Peak, Nev	8,000
	Kings Mountain, N.C.[1]	6,000
Kerr-McGee Corp	Searles Lake, Calif	1,000

[1]Onstream December 1976.

Lithcoa operated an open pit mine and a beneficiation plant at Bessemer City, N.C., where it has a reserve of 29.6 million tons of spodumene ore, averaging 1.38% Li_2O, in pegmatite dikes. All of Lithcoa's mill output, exclusive of concentrate tolled for others, provided feed for its chemical plant in Gastonia, N.C., where more than 70 different lithium products were manufactured, of which 30 were marketed in commercial quantities. Products of major importance included lithium hydroxide, lithium carbonate, lithium chloride, lithium bromide, lithium hypochlorite, butyllithium and lithium metal. During 1976, approximately 39% of Lithcoa's sales were absorbed by foreign markets. The balance went to several hundred customers in many diverse industries in the United States, no single customer accounted for more than 10% and no single industry for more than 30% of total sales. In addition, feldspathic sands were produced by Spartan Minerals Co. of Pacolet, S.C., a subsidiary of Lithcoa, from feldspar-rich mill tailings of the parent company and marketed to the ceramic and glass container industries. Currently, Lithcoa reportedly accounts for half of the lithium production in market economy countries, and plans are underway to expand capacity of the Gastonia plant to 22,000 tons of lithium carbonate equivalent, at an estimated cost of $12 million.

Foote Mineral Co., 92% owned by Newmont Mining Corp., has an open pit mine and beneficiation plant at Kings Mountain, N.C., where reserves are estimated to be adequate to sustain forecasted production levels for more than 40 years. It was the major supplier of spodumene concentrates to the ceramic industry. At yearend 1976 a new lithium carbonate facility came onstream at Kings Mountain, adding approximately 6,000 tons to the total annual capacity of market economy countries. An additional source of lithium carbonate evolves from Foote's brine operations at Silver Peak, Nev., conducted under sodium and potassium leases and prospecting permits issued by the Bureau of Land Management of the U.S. Department of the Interior.

During the fourth quarter of 1976, Foote completed modification of its Sunbright, Va., lithium hydroxide facility. With an estimated annual capacity of 2,500 tons of lithium hydroxide monohydrate, the plant will utilize lithium carbonate from the Kings Mountain operations as plant feed. A variety of other lithium chemicals were also produced by Foote at Fraser, Pa., and at New Johnsonville, Tenn., where organolithium products such as normal butyllithium and secondary butyllithium were manufactured.

Minor amounts of lithium carbonate, approximately 900 tons per year [3], continued to be extracted as a byproduct of Kerr-McGee's brine operations at Searles Lake, Calif. Although the Searles Lake potash operations are being expanded, it is understood that no increase in lithium carbonate capacity is envisaged.

CONSUMPTION AND USES

Lithium minerals, compounds and metal command a variety of industrial and institutional uses. The minerals lepidolite, petalite, and spodumene find direct application in specialty glasses, enamels, glazes, and whitewares. Small amounts of spodumene in glasses, about 0.1% to 0.2% lithia, reduce operating temperatures and fuel consumption and increase pull and furnace life. Also, the addition of spodumene in container glass batches is believed to reduce stack emissions of fluorides and provides for the chemical durability of the glass. Lithium additives were incorporated in U.S. specifications for black and white television tubes many years ago, and other countries have presumably adopted the same specifications. It is understood that a 21-inch tube

[3]Rykken, L. E. Lithium Production From Searles Valley. Ch. in Lithium Resources and Requirements by the Year 2000. U.S. Geol. Survey Prof. Paper 1005, 1976, pp. 33-34.

utilizes about 0.2 pound of lithia. Recrystallized glasses, a relatively recent development, utilize low-iron spodumene or petalite to impart strength and durability. Supplemented by lithium compounds, spodumene or petalite is used in quantities making up as much as 50% of the glass batch. In enamels and glazes, an addition of about 1% lithia in ground and cover coat frits increases the fluidity of the coats, improves gloss, and produces a high-strength glaze with low thermal expansion. In whitewares, lithia is added in various amounts depending on whether it is used as a fluxing agent or as a low-expansion constituent. As a flux, spodumene can impart lower absorption to china bodies than can be obtained with feldspar alone. Also, maturing temperatures are decreased and strength is increased with spodumene additions. Larger amounts of lithia in whiteware bodies result in a marked reduction in thermal expansion and improved resistance to thermal shock. In addition to direct-use ores, various amounts of lithium carbonate, lithium fluoride, lithium borosilicate, and lithium manganite are also used in glass and ceramic applications. In 1976, total consumption of lithium, in all forms, by the glass and ceramic industries was estimated at 4,700 tons of Li_2CO_3 equivalent, up 6% from 1975 consumption.

Table 4.—Estimated domestic consumption of lithium

(Short tons of Li_2CO_3 equivalent)

End Use	1975	1976
Aluminum production	6,500	7,500
Ceramics and glass	4,450	4,700
Lubrication	1,350	1,400
Air-conditioning	800	700
Synthetic rubber	500	600
Others	400	400
Total	14,000	15,300

By far the most significant development in recent years has been the increased use and perhaps final acceptance of lithium carbonate in aluminum potlines. The addition of lithium carbonate to the electrolyte baths results in a 25% reduction in fluoride emissions, a 10% reduction in power requirements, and a 7% to 10% increase in potline capacity. The optimum concentration of lithium in the bath appears to be 4% to 5% of the bath content. In new cells, absorption of lithium by the potlining is abnormally high, and it is sometimes preferable to initiate lithium additives only after the first 2 months of operation. Typically, a 100,000-ton-per-year potline is thought to require an initial charge of 600 tons of lithium carbonate, and an additional makeup charge of 250 tons is required annually to compensate for process losses. The initial charge is needed only at the startup of a new cell. At the end of the cell life, usually after 3 years or 1,000 tons of aluminum, the contents of the cell are recycled by transferance to a new cell. In consequence, this makeup charge will very likely constitute the major end use of lithium carbonate in aluminum potlines over the long haul. According to the Aluminum Association, domestic production of primary aluminum in 1976 amounted to 4.25 million tons, up about 10% from that of 1975. It is estimated that 35% of the production came from potlines using lithium carbonate, the consumption of which probably amounted to 7,500 tons.

As a raw material in the manufacture of greases, the use of lithium hydroxide monohydrate has expanded considerably over the past 25 years at the expense of calcium and sodium compounds. Today, over half of all greases produced domestically are lithium-based. Lithium hydroxide monohydrate is added to lubricating oils where it saponifies into lithium stearate and acts as a thickener. Major advantages of lithium greases include effectiveness over a wide range of temperatures, from subzero to over 300°C, good water resistance, resistance to oxidation, and stability under cyclic heating and cooling. The lithium content of the greases varies but is understood to average 1.2% lithium hydroxide monohydrate. According to the National Lubricating Grease Institute, 69% of member producers responding to a national survey reportedly produced some 244 million pounds of lithium greases in 1975. Presumably, the remaining 31% who chose not to respond represented minor producers with little or no lithium grease production. Thus, total lithium grease production in 1975 is estimated at 256 million pounds, requiring approximately 3.07 million pounds of lithium hydroxide monohydrate, or 2.70 million pounds of lithium carbonate equivalent. While a more recent survey has yet to be commissioned, it may be estimated that lithium grease production in 1976 probably amounted to some 265 million pounds, requiring about 3.18 million pounds of lithium hydroxide monohydrate, or 2.80 million pounds of lithium carbonate equivalent.

Lithium bromide is used in absorption air-conditioning systems because it is hygroscopic, is able to maintain a constant humidity in air, and is soluble at low temperature. On account of their size, absorption machines constitute only a minor component of the total air-conditioning and refrigeration market. Typically, a 100 refrigerated-ton system uses about 1,500 pounds of lithium bromide, while a 1,250-refrigerated-ton machine uses 8,000 pounds. Since 1967, when some 2,700 absorption units were assembled, production has declined and by 1975 only 730 units were reportedly assembled. A further erosion probably occurred in 1976 owing to a drop in commercial and industrial building starts. While the capacities of the machines are generally not known, lithium bromide consumption probably did not exceed 1,900 tons in 1975 and 1,600 tons in 1976, equivalent to 800 tons and 700 tons of lithium carbonate in those 2 years.

Several organolithium compounds are used as catalysts in the manufacture of polymers in the chemical industry, and perhaps the most important usage in this field is that of n-butyllithium in synthetic (polyisoprene) rubber production. Among alkali- metal-based catalysts, n-butyllithium is found to be the most effective in directing the reaction towards the cis-1,4 structure which confers properties most closely resembling those of natural rubber. While polyisoprene rubber accounts for about 10% of total domestic production of all synthetic rubber, it is believed that only a part of this 10% is made using lithium catalysts. Reliable estimates of the consumption of organolithium compounds are currently unavailable but it is probably about 500 to 600 tons lithium carbonate equivalent per year.

Miscellaneous applications of lithium and its compounds are found in storage batteries, pharmaceuticals, paints, dyes, resins, laundry bleach and bactericide, welding and brazing fluxes, and specialty alloys, all of which account for perhaps no more than 400 tons of lithium carbonate equivalent consumed annually. Two applications, a rechargeable lithium battery for automobile propulsion and thermonuclear fusion reactors, currently under various stages of development, may well alter the future consumption pattern if proven successful.

PRICES

Yearend prices of elemental lithium and its typical compounds posted gains in 1976. Among high-volume products marketed, lithium carbonate had price increases of 6% to 9%; lithium hydroxide monohydrate, 8%; lithium bromide, 17%; and lithium chloride, 8% to 31%. High value products included lithium metal and lithium hydride, prices of which rose 5% to 35% and 2% to 31%, respectively.

Table 5.—Domestic prices of lithium and lithium compounds

(Dollars per pound)

	1975	1976
Lithium bromide:		
Anhydrous, drums, delivered	3.00	3.50
Lithium carbonate:		
powdered, bags, delivered	0.755-0.795	0.825-0.840
Lithium chloride:		
anhydrous, delivered	1.26-1.53	1.65
solution, drums, delivered	1.47	1.47
Lithium fluoride:		
drums, delivered	2.42	2.52-2.70
Lithium hydride: delivered	9.25	9.45-12.08
Lithium hydroxide monohydrate:		
drums, delivered	1.18	1.27
Lithium hypochlorite: works	0.52	0.52
Lithium metal:		
99.9% ingots, thousand-pound lots, delivered	11.10	11.60-15.00
Lithium nitrate:		
technical grade, drums, 100-pound lots	1.41	1.59-1.64
Lithiuim stearate:		
50-pound cartons, freight allowed	0.95	0.94-0.95
Lithium sulphate:		
drums, 100-pound lots	1.55	1.43-1.75

Source: Chemical Marketing Reporter.

Table 6.—Lithium metal and chemicals: Apparent U.S. exports[1] to selected countries

(Short tons)

Commodity	Belgium-Luxembourg	France	Germany, West	Italy	Japan	Netherlands	Spain	Total	Total lithium content
1975									
Gross weight:									
Lithium carbonate	11	[r]122	1,968	74	495	--	[r]27	[r]2,697	[r]507
Lithium hydroxide[2]	49	332	279	[r]73	[r]388	[r]115	[r]115	1,351	223
Lithium chloride	NA	NA	[r]30	--	1	NA	--	[r]31	5
Lithium bromide	NA	NA	NA	NA	[3]3	NA	NA	[3]3	(4)
Lithium metal	1	[r]4	23	(4)	7	[r](4)	--	[r]35	[r]35
Lithium content (total)	[r]11	[r]82	444	26	164	19	24	[r]770	[r]770
1976									
Gross weight:									
Lithium carbonate	53	96	2,707	27	1,096	--	74	4,053	762
Lithium hydroxide[5]	24	158	194	48	430	115	121	1,090	180
Lithium chloride	NA	NA	18	--	1	NA	--	19	3
Lithium bromide	NA	NA	NA	NA	[3]1	NA	NA	[3]1	(4)
Lithium metal	--	(4)	14	(4)	--	--	(4)	14	14
Lithium content (total)	14	44	558	13	277	19	34	959	959

[r]Revised. NA Not available.

[1]Only in the case of lithium hydroxide are U.S. exports of lithium chemicals reported seperately in official U.S. trade statistics. Other lithium compounds as well as lithium metal are reported in basket categories. Data in this table are derived from import statistics of the listed major trading partner countries.

[2]Officially reported U.S. exports total 613 short tons, distributed as follows: Belgium-Luxembourg—15, Bolivia—12, Brazil—2, Canada—25, Chile—9, France—143, West Germany—33, India—29, Indonesia—42, Iran—2, Ireland—2, Japan—117, Mexico—54, the Netherlands—49, Pakistan—3, the Philippines—2, the Republic of South Africa—11, Spain—11, Sweden—5, Switzerland—8, Thailand—5, and the United Kingdom—35.

[3]Figures represent estimated gross weight of lithium bromide included in a basket category of lithium bromide and potassium bromide (50% of the total of lithium bromide and potassium bromide is assumed to be lithium bromide).

[4]Less than 1/2 unit.

[5]Officially reported U.S. exports total 267 short tons, distributed as follows: Argentina—1, Belgium-Luxembourg—1, Canada—6, France—30, India—10, Israel—11, Japan—77, the Republic of Korea—1, Mexico—31, the Netherlands—39, Spain—41, Switzerland—17, and the United Kingdom—2.

FOREIGN TRADE

Exports of lithium hydroxide declined substantially in 1976, particularly to France and Japan, which were major recipients in 1975. Totally clouding the export picture is the lack of data on shipments of lithium carbonate and other lithium compounds. A clearer picture of U.S. exports may be gleaned from import statistics of major trading partner countries.

Official trade statistics are generally incomplete and in some cases inaccurate. According to the Bureau of the Census, U.S. Department of Commerce, imports of lithium ores dropped to about 68 tons in 1976 from about 4,548 tons in 1975. On the other hand, imports of lithium compounds rose to some 42 tons, compared with 10 tons in 1975. It is not entirely clear what lithium compounds were imported in 1975-76 or in years past.

Table 7.—U.S. exports of lithium hydroxide

Destination	1975 Quantity (pounds)	1975 Value (dollars)	1976 Quantity (pounds)	1976 Value (dollars)
Argentina	--	--	2,600	4,032
Belgium	30,700	37,452	2,000	3,260
Bolivia	24,150	39,382	--	--
Brazil	4,000	4,248	--	--
Canada	50,000	51,404	12,000	15,532
Chile	16,800	38,027	--	--
France	284,592	417,481	60,016	105,030
Germany, West	66,700	84,099	--	--
India	57,820	85,176	20,975	22,865
Indonesia	83,406	129,835	--	--
Iran	3,370	14,760	--	--
Ireland	4,545	11,363	--	--
Israel	--	--	22,000	2,684
Japan	234,759	205,709	153,617	192,368
Korea, Republic of	--	--	2,095	3,100
Mexico	108,600	112,608	62,000	73,160
Netherlands	98,676	169,360	78,475	91,472
Pakistan	6,800	9,724	--	--
Philippines	4,400	3,282	--	--
South Africa, Republic of	22,000	26,290	--	--
Spain	22,000	26,972	82,220	90,007
Sweden	8,802	10,089	--	--
Switzerland	15,600	17,472	33,200	36,012
Thailand	8,800	18,656	--	--
United Kingdom	69,722	79,242	3,000	34,944
Total	1,226,242	1,592,631	534,198	674,466

Source: U.S. Department of Commerce, Bureau of the Census.

Table 8.—U.S. imports for consumption of lithium bearing materials

Commodity and country	1975 Gross weight (pounds)	1975 Value (thousand dollars) Customs	1975 Value (thousand dollars) C.I.F.	1976 Gross weight (pounds)	1976 Value (thousand dollars) Customs	1976 Value (thousand dollars) C.I.F.
Lithium ores:						
Brazil	9,096,127	538	695	--	--	--
Canada	--	--	--	136,000	1	1
Total	9,096,127	538	695	136,000	1	1
Organic acid lithium salts:						
Mexico	--	--	--	12,438	6	6
Lithium compounds, n.e.c.:						
France	13,645	63	65	69,839	506	512
Germany, West	698	7	7	484	15	15
Japan	--	--	--	13,227	87	91
Spain	6,614	33	34	--	--	--
Switzerland	--	--	--	1,102	1	1
United Kingdom	111	4	4	100	6	6
Total	21,068	107	110	84,752	615	625

WORLD REVIEW

Worldwide, consumption of lithium in all forms increased approximately 8% over that of 1975, reflecting a general recovery from the recession of that year. As with the United States, the use of lithium carbonate in the aluminum industry of Europe is steadily rising, to make it a major end use for lithium. While in past years lithium carbonate had not been consumed in significant quantities in the aluminum potlines in Japan, it is likely that there is now a growing acceptance of the additive, especially in the face of escalating energy costs.

Ranking among the major consumers of lithium ores and compounds are the glass and ceramics industries of Europe and Japan. A pottery and whiteware industry has thrived in Japan since early times and today represents an important contributor to export earnings. Japan is also the world leader in the production of black-and-white television receivers, which utilize lithium additives in the composition of the tubes.

Absorption air-conditioning, a major end user of lithium bromide, showed a slight downturn in the United States and a dramatic decline in Japan during 1976. This use for lithium is expected to recover gradually with a recovery in commercial and industrial building starts.

There is a dearth of published information on actual world lithium consumption by end uses, and table 13, which represents gross estimates, must be interpreted with caution.

Argentina.—While official statistics are unavailable, it is believed that Argentina has a small annual production, not more than 300 tons of crude lithium ore, mainly from minor workings in the States of San Luis, Cordoba, and Catamarca. Minable reserves in these areas are estimated at 154,000 tons.

Australia.—Despite the lifting of a ban of lithium exports to centrally planned economy countries in 1967, Australia has not been a significant lithium producer even though reserves in excess of 4 million tons are known, particularly in Western Australia. Most Australian production, probably several hundred tons of petalite per year, is a byproduct from a feldspar quarry at Londonderry, near Coolgardie, operated by Australian Glass Manufacturers Co. Intermittent shipments of petalite ore have been made to consumers in the United States and Japan in some years, and it is likely that production has been curtailed or suspended in recent times.

Bolivia.—Preliminary investigations by the U.S. Geological Survey have confirmed the presence of large, high-grade deposits of lithium and potassium in the Salar de Uyuni and nearby salars in southwestern Bolivia.[4] The lithium is contained primarily in brines, salt crusts, and interbedded clays, and indications are that the deposits may rank among the largest known lithium reserves in the world. Plans for commercial development have not been announced, but it is understood that major U.S. producers have shown some interest in their further exploration.

Brazil.—An important source of ceramic-grade lithium minerals is Brazil, where the only known concessions are held by Companhia Estanifera do Brasil (CESBRA), partly owned by Patino Mining Corp. of Canada. The concessions cover some 29 outcrops discovered at Aracuai in the Province of Minas Gerais. Small amounts of hand-cobbed spodumene ore have been produced for domestic consumption and export. Other areas producing minor amounts of spodumene and amblygonite as byproducts of beryl mining include the northern provinces of Paraíba, Rio Grande do Norte, and Ceará. In addition to crude ore, some lithium carbonate, not more than 50 tons annually, is produced presumably by Orquima S.A. Total minable reserves in the producing provinces are estimated at a little over 800,000 tons.

Canada.—Although substantial deposits of lithium minerals are known in Canada, there has been no commercial exploitation since 1965 when the Quebec lithium division of the Sullivan Mining Group ceased operations at Amos, Quebec. The Quebec lithium property consists of pegmatite dikes, individually up to 2,000 feet in length and 100 feet in width. Total reserves have been estimated at 20 million tons of spodumene grading about 1.2% lithia.

As a result of recent developments on lithium deposits at Bernic Lake, the Province of Manitoba may well emerge as a significant producer. Situated some 110 miles northeast of Winnipeg, lithium occurs in pegmatite zones within the world's larg-

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[4]Ericksen, G.E., J.D. Vine, and R.A. Ballon. Lithium-Rich Brines at Salar de Uyuni and Nearby Salars in Southwestern Bolivia. U.S. Geol. Survey Open-file Report No. 77-615, 48 pp.

est tantalum deposit and its only known commercial deposit of pollucite. A spodumene zone containing 5 million tons of 3% lithia over a width of 30 feet occurs in the main pegmatitic sill, and exploratory drilling underground indicates additional ore beneath present workings. For years tantalum and cesium have been extracted from Bernic Lake by Tantalum Mining Corp. (Tanco), a joint venture of Chemalloy Minerals of Toronto, the Manitoba Development Corp. (MDC), and Kawecki Berylco Industries (KBI) of New York. In 1973 a pilot plant was installed for the beneficiation of spodumene ore. Trial shipments to consumers during the year demonstrated the suitability of the concentrate for ceramic applications. Soon after KBI's acquisition of a 25% interest in Tanco in 1974, plans were laid for upgrading lithium production with a lithium carbonate facility. Scheduled for completion in 1976, the pilot plant is designed to process 100 tons of concentrate per day. Further into the future, mine and plant expansions will increase output to 15,000 tons of low-iron spodumene concentrate and 6,000 to 7,000 tons of lithium carbonate.

Chile.—About to become a potentially important lithium source are the subsurface potassic brines in the Salar de Atacama of northern Chile. The lithium occurs in very rich brines which are estimated to contain 1.2 million tons of lithium and 14 million tons of K_2O. Corporación de Fomento de La Produccion (CORFO) reports that Foote Mineral Co. has signed an agreement with the Chilean Government for the commerical development of these deposits. Foote, which owns 55% of CORFO, is reportedly planning a $10 million investment in the project.

China, People's Republic of.—Although high-purity lithium metal is produced for atomic energy applications, very little else is known about the lithium industry of the People's Republic of China. Two salt lakes, Charkhan and Idsaydam, in the Tsaidam basin of Tsinghai are believed to be similar in chemical composition to Searles Lake in California. It has been suggested that lithium is probably being extracted as a byproduct of borate and potash operations at these lakes.

France.—Some lithium compounds, particularly lithium hydroxide for use in grease manufacture, have been produced in France by Rhône-Poulenc, presumably from imported ore and carbonate.

Germany, West.—A major processor in Europe is Metallgesellschaft AG, which operates from the Hans-Heinrich- Hütte plant at Langelsheim and produces a wide variety of lithium compounds as well as lithium metal. Until recently, the main source of Metallgesellschaft's ore has been spodumene from Kings Mountain, N.C., under an agreement with Foote Mineral Co. dating from 1964. Today, feedstock for the Langelsheim plant comprises lithium carbonate from the United States and the U.S.S.R. as well as surplus lithium hydroxide from the U.S. Government.

Japan.—Japan ranks among the world's major consumers and processors of lithium minerals and compounds, all of which are imported. Honjo Zinc Co., a leading processor, utilizes lithium carbonate and lithium hydroxide from the United States and the U.S.S.R. to produce a variety of secondary lithium products, including lithium chloride and bromide. Asahi Glass, part of the Mitsubishi Group, has been manufacturing about 240 tons of lithium bromide monthly at Kita, Kyushu, and reportedly has a production capacity of 300 tons per month. Nihon Lithium, a joint venture of Foote Mineral Co., and Sumitomo Shoji, is not yet a lithium processor but plans to produce some 300 tons of lithium bromide, 100 tons of lithium chloride, and 30 tons of butyllithium annually in the future. Meanwhile, Asian Lithium Co., a joint venture of lithium Corp. and Honjo Zinc, has been producing butyllithium for domestic consumption since its inception in late 1971.

Mozambique.—Minor amounts of lepidolite have been produced intermittently in the Zambesia district of Mozambique, possibly by Empressa Mineira do Alto Ligohna Ltda. Although substantial shipments of lithium minerals have been made to Belgium and the Netherlands in recent years, it is believed that they represent Rhodesian production.

Rhodesia, Southern.—Lithium minerals are widespread in Southern Rhodesia, occurring in the tin fields of Bikita; in the districts of Salisbury, Umtali, Mtoko, and Gwanda; and at Mozoe, Fort Rixon, Shamva, Inyanga, and near Gadzema. The most important occurrence is at Bikita, where lithium pegmatites contain substantial amounts of lepidolite and petalite, with lesser amounts of spodumene and eucryptite. Reserves of hand pickable ore are estimated at over 5 million tons averaging 2.5% lithia. Prior to United Nations trade sanctions against Rhodesia in 1968, Bikita Minerals Ltd., a subsidiary of Selection Trust Ltd., was a major world producer of lithium minerals with an annual output exceeding 60,000 tons, most of which was exported. Since then production has declined and while official statistics have not been available, it is believed that production has been suspended and shipments are being made from stockpile. Small amounts of lithium carbonate may be produced by a local company, Lithium Products Ltd., in Gwelo.

South Africa, Republic of.—As with Mozambique, South Africa's production of lithium minerals, principally by the Otavi Mining Co. Ltd. at Mica, Transvaal, has been insignificant. Shipments made to Europe in recent times probably represent output from Southern Rhodesia and South-West Africa.

South-West Africa, Territory of.—S.W.A. Lithium Mines Ltd., acquired in 1968 by Klockner & Co., a West German industrial group, produces lepidolite and petalite and small quantities of amblygonite from the Helicon and Rubicon mines southeast of Karibib. Reserves of hand-cobbed ore are said to be minimal, but more than 1 million tons of millable ore is known to be available for upgrading in a 10,000-ton-per-year flotation plant.

U.S.S.R..—Lithium occurrences in the U.S.S.R. are numerous and widespread. The more important include spodumene in the Kola Peninsula; lepidolite and spodumene in Muzinskoe, Lipovka, and Boevskoe in the Urals; spodumene and lithium phosphate in the Kablinsk and Turkestan ranges; spodumene, lepidolite, and petalite in the Transbaikal Territory in Siberia; and lithium micas in Volynia in the Ukraine. Also, several lakes in the Minusinsk-Abakansk area in old Transbaikal may have commercial concentrations of lithium in brines. For many years now the U.S.S.R. has marketed in Europe and Japan between 1,000 and 3,000 tons annually of lithium salts, mainly lithium carbonate and lithium hydroxide. Presumably, the lithium hydroxide is deficient in the Li-6 isotope and can only represent stockpiled residue from Li-6 processing. At the same time it is quite likely that spodumene in the Kola Peninsula is currently being mined and processed into lithium chemicals for domestic consumption and export. In view of the growing domestic demand, it is believed that exports of lithium compounds will be sharply curtailed or else suspended in years to come.

Table 9.—Lithium minerals: World production, by country

(Short tons)

Country[1] and mineral produced	1974	1975	1976[p]
Argentina (minerals not specified)	181	276	[e]275
Australia	1	--	--
Brazil:			
Amblygonite	188	172	
Lepidolite	507	516	[e]2,200 (total of Brazil minerals)
Petalite	3,934	4,075	
Spodumene	[e]1,320	873	
Canada, spodumene[2]	786	--	62
China, People's Republic of (minerals not specified)[e 3]	10,000	10,000	10,000
Portugal, lepidolite	1,323	1,323	1,213
Rhodesia, Southern (minerals not specified)[e 3]	15,000	20,000	20,000
Rwanda, amblygonite[e]	30	30	30
South Africa, Republic of, spodumene	1	--	--
South-West Africa, Territory of (minerals not specified)[4]	41,625	56,849	5,915
U.S.S.R. (minerals not specified)[e 3]	50,000	50,000	50,000
United States (minerals not specified)	W	W	W

[e]Estimate. [p]Preliminary. W Withheld to avoid disclosing individual company confidential data.

[1]In addition to the countries listed, other nations may produce small quantities of lithium minerals, but output is not reported and no valid basis is available for estimating production levels.

[2]Figures presented are U.S. imports from Canada; official Canadian sources report no production since 1965, but the United States has imported lithium minerals from Canada in most years since that time. It is not clear whether these imports are from: accumulated stocks, test production quantities not reported in official Canadian statistics, Canadian imports, or a combination of these sources.

[3]These estimates denote only an approximate order of magnitude; no basis for more exacting estimates is available. Outputs by the People's Republic of China and the U.S.S.R. have not been reported since 1964.

[4]Output has not been officially reported since 1966, but presumably has continued since a number of countries record imports from South Africa.The total quantity considerably exceeds reported output by the Republic of South Africa proper, and presumably include shipments from South-West Africa. Quantities given represent imports by the United States and the European Community reported as originating in South Africa, but the reader is cautioned that a portion of the material may have been mined in Southern Rhodesia. In 1966, actual output from South-West Africa totaled 1,739 short tons, as follows: amblygonite 30 tons; lepidolite, 365 tons; petalite, 1,344 tons.

Table 10.—Reported world trade in lithium chemicals[1]

(Short tons of contained lithium)

Importing countries	United States 1975	United States 1976	U.S.S.R. 1975	U.S.S.R. 1976	Germany, West 1975	Germany, West 1976	Other 1975	Other 1976	Total 1975	Total 1976
Belgium-Luxembourg:										
Carbonate	2	10	2	1	([2])	--	r11	--	r15	11
Hydroxide	8	4	2	--	15	13	2	--	27	17
Chloride	NA	NA	NA	NA	[3]--	[3]--	NA	NA	[3]--	[3]--
Metal	1	--	--	--	2	([2])	([4])	--	r3	([2])
Total	r11	14	4	1	r17	13	r13	--	r45	28
France:										
Carbonate	23	18	r1	25	21	36	r([2])	3	r45	82
Hydroxide	55	26	12	17	r18	25	r8	--	r93	68
Chloride	NA	NA	NA	NA	[3]9	[3]12	NA	NA	[3]9	[3]12
Metal	r4	([2])	--	--	3	6	([4])	--	r7	6
Total	r82	44	r13	42	r51	79	r8	3	r154	168
Germany, West:										
Carbonate	370	509	44	20	XX	XX	r4	22	r418	551
Hydroxide	46	32	19	18	XX	XX	r17	11	r82	61
Chloride	5	3	--	--	XX	XX	r([2])	([2])	r5	3
Metal	23	14	([4])	--	XX	XX	([4])	--	r23	14
Total	444	558	r63	38	XX	XX	r21	33	r528	629
Italy:										
Carbonate	14	5	r10	1	14	12	r3	7	r41	25
Hydroxide	12	8	6	--	22	18	2	([2])	42	26
Chloride	--	--	--	--	[3]5	[3]7	--	--	[3]5	[3]7
Metal	([2])	([2])	--	--	15	3	([4])	--	r15	3
Total	26	13	r16	1	r56	40	r5	7	r103	61
Japan:										
Carbonate	93	206	42	27	--	--	([2])	([2])	135	233
Hydroxide	64	71	31	22	--	([2])	--	([2])	95	93
Chloride	([2])	([2])	--	--	--	([2])	--	--	([2])	([2])
Bromide	([2])([5])	([2])([5])	--	--	--	([2])([5])	--	--	([2])([5])	([2])([5])
Metal	7	--	([2])	--	([2])	--	([2])	--	7	--
Total	164	277	73	49	([2])	([2])	([2])	([2])	237	326

See footnotes at end of table.

Table 10.—Reported world trade in lithium chemicals[1] —Continued

(Short tons of contained lithium)

Importing countries	Source countries									
	United States		U.S.S.R.		Germany, West		Other		Total	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Netherlands:										
Carbonate	--	--	--	--	--	--	--	--	--	--
Hydroxide	19	19	6	5	r(2)	7	r(2)	--	r25	31
Chloride	NA	NA	NA	NA	3 14	3 14	NA	NA	3 14	3 14
Metal	(2)	--	--	--	1	(2)	--	--	1	(2)
Total	19	19	6	5	15	21	r(2)	--	r40	45
Spain:										
Carbonate	5	14	2	--	(2)	(2)	(2)	--	7	14
Hydroxide	19	20	3	--	7	6	1	(2)	30	26
Chloride	--	--	--	--	(2)	(2)	(2)	(2)	(2)	(2)
Metal	--	(2)	--	--	--	(2)	21	(2)	21	(2)
Total	24	34	5	--	7	6	22	(2)	58	40
Other countries:										
Carbonate	(2)	(2)	NA	NA	3 5	3 7	NA	NA	3 5	3 7
Hydroxide	NA	NA	NA	NA	3 33	3 52	NA	NA	3 33	3 52
Chloride	NA	NA	NA	NA	3 6	3 9	NA	NA	3 6	3 9
Metal	1	3	NA	NA	3 13	3 5	NA	NA	r14	8
Total	r1	3	NA	NA	57	73	NA	NA	r58	76
Total:										
Carbonate	r507	762	r101	74	40	55	r18	32	r666	923
Hydroxide	223	180	79	62	r95	121	r30	11	r427	374
Chloride	5	3	--	--	34	42	r(2)	(2)	r39	45
Bromide	(2)	(2)	--	--	--	(2)	--	--	(2)	(2)
Metal	r36	17	r(2)	--	34	14	r21	(2)	r91	31
Total	r771	962	r180	136	r203	232	r69	43	r1,223	1,373

rRevised. NA Not available. XX Not applicable.

[1]Compiled from import statistics of listed importing countries unless otherwise noted. Conversion from reported metric tons to short tons was accomplished by multiplying metric tons by 1.10231. Conversions to lithium content from reported gross weights were accomplished through the use of the following conversion factors: lithium carbonate, multiply by 0.188; lithium hydroxide, multiply by 0.165; lithium chloride, multiply by 0.164; lithium bromide, multiply by 0.080. It should be noted that most of the countries provide data for a basket category of "lithium oxide and hydroxide"; this has been assumed to be largely, if not entirely, the monohydrate form of lithium hydroxide ($LiOH \cdot H_2O$), and the factor selected for converting this material to lithium content is based on this assumption.

[2]Less than 1/2 unit.

[3]Source: West German official export statistics.

[4]Revised to zero.

[5]Source publication reports imports of the total of lithium bromide and potassium bromide as a single figure; entry here is an estimate based on the assumption that half of the total is lithium bromide.

[6]Totals are of listed figures only; as such, they are only partial totals in most instances.

Table 11.—Lithium mineral concentrate: Imports of selected countries, by country of origin[1]

(Short tons, gross weight)

Source country	Recipient country										
	Belgium-Luxembourg	Denmark	France	Germany, West	Ireland	Italy	Japan	Netherlands	United Kingdom	United States	Total
1975											
Producing countries:											
Brazil	--	--	--	--	--	--	--	--	--	4,548	4,548
Canada	--	--	--	--	--	--	--	--	--	--	--
Mozambique	(2)	--	--	--	--	--	--	[3]1,465	--	--	r1,465
South Africa, Republic of[4]	3,747	--	656	r3,304	--	535	--	[3]567	54,424	--	r63,233
United States	--	--	245	353	--	--	--	[3]44	2,612	XX	r3,254
Nonproducing countries:											
Belgium-Luxembourg	XX	--	--	--	--	--	--	--	--	--	--
Germany, West	--	--	--	XX	--	--	--	[3]153	--	--	153
Greece	--	--	--	--	--	--	--	[3]2,522	31,266	--	r33,788
Italy	--	--	--	--	--	XX	--	--	82,467	--	82,467
Netherlands	306	--	348	64	--	r196	--	XX	261	--	r1,175
Unspecified countries	r1,002	r35	301	r161	--	r120	--	[3]906	2,916	--	r5,441
Total	5,055	r35	1,550	r3,882	--	851	--	[3]5,657	173,946	4,548	r195,524
1976											
Producing countries:											
Brazil	--	--	--	--	--	--	[5]1,308	--	--	--	[5]1,308
Canada	--	--	--	--	--	--	--	--	--	68	68
Mozambique	--	--	--	--	--	--	--	[3]593	--	--	593
South Africa, Republic of[4]	1,084	--	1,181	4,130	126	--	--	[3]3,745	--	--	10,266
United States	--	--	463	419	--	--	--	[3]138	--	XX	1,020
Nonproducing countries:											
Belgium-Luxembourg	XX	--	--	--	--	--	--	--	--	--	--
Germany, West	--	--	--	XX	--	--	--	--	--	--	--
Greece	--	--	--	--	--	--	--	[3]3,616	--	--	3,616
Italy	--	--	--	--	--	XX	--	--	--	--	--
Netherlands	346	--	288	200	--	389	--	XX	72	--	1,295
Unspecified countries	14	35	251	--	12	194	--	--	--	--	506
Total	1,444	35	2,183	4,749	138	583	1,308	[3]8,092	72	68	18,672

rRevised. XX Not applicable.
[1]Compiled from import statistics of listed recipient countries.
[2]Revised to zero.
[3]Data may include minerals other than lithium concentrates. Nonexpanded vermiculite, chlorite, and perlite, if any, are included.
[4]Includes materials from the Territory of South-West Africa and possibly Southern Rhodesia.
[5]Source: Official trade statistics of Brazil.

Zaire.—Following the discovery in 1975 of some 35 million tons of spodumene ore in the Manano pegmatites in Zaire, Zairetain, a Government-owned mining company, announced plans for the commercial development of the ore. Included in the plans is the construction of a spodumene concentrator and a 5,000-ton-per-year lithium carbonate plant. The Government of Zaire has since been in consultation with a major U.S. lithium producer in connection with the proposed project, and it is understood that the World Bank may be asked for financial assistance in feasibility studies on the property.

Table 12.—Estimated world consumption of lithium

(Short tons of lithium carbonate equivalent)

	1971	1972	1973	1974	1975	1976
United States	9,750	13,000	15,250	16,000	14,000	15,300
Western Europe	3,500	3,500	3,500	3,650	3,000	3,250
Japan	1,000	1,000	2,000	1,800	1,500	1,600
U.S.S.R	500	500	3,000	4,000	4,000	4,000
Others	600	500	1,000	1,250	1,500	1,750
Total	15,350	18,500	24,750	26,700	24,000	25,900

Source: Mining Annual Review, 1976 and 1977.

Table 13.—Estimated world consumption of lithium, by end use, in 1976

(Short tons Li_2CO_3 equivalent)

End use	United States	Western Europe	Japan	U.S.S.R.	Rest of world	Total
Aluminum production	7,500	800	200	1,200	200	9,900
Ceramics and glass	4,700	800	450	600	500	7,050
Lubrication	1,400	800	300	1,000	500	4,000
Air-conditioning	700	200	300	300	300	1,800
Synthetic rubber	600	400	250	500	200	1,950
Others	400	250	100	400	50	1,200
Total	15,300	3,250	1,600	4,000	1,750	25,900

TECHNOLOGY

After a hiatus of nearly 50 years, electric vehicles are poised for a comeback. Pressure to conserve petroleum supplies and to preserve the environment has stepped up funding, through the Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976, for advanced battery systems capable of meeting energy requirements of a short-range commuter-type vehicle. Among those under various stages of development, through ERDA contracts administered by Argonne National Laboratory, is a lithium-sulfur battery whose unit cell consists of a solid lithium-aluminum cathode, an iron sulfide or disulfide anode, and a molten salt eutectic of lithium chloride and potassium chloride. The electrolyte has a melting point of 352°C, and because cell operating temperatures are between 380° and 450° C, the batteries require thermal insulation. Developed at Argonne, the cell has a theoretical energy density of 430 watt-hours per pound, but because alloys and metal sulfide compounds are used (instead of elemental lithium and sulfur), Argonne's target density is 80 to 85 watt-hours per pound. At the Atomics International, division of Rockwell International, a similar cell with a lithium-silicon cathode has been successfully tested, demonstrating the technical feasibility of building large, high-density batteries of this type. More recently, Exxon Enterprises has revealed promising research on a lithium battery that operates at room temperature. The Exxon battery employs metallic lithium for the cathode and titanium disulfide for the anode and has a lithium perchlorate electrolyte. The battery is expected to have an energy density of 50 to 60 watt-hours per pound, lower than higher temperature lithium batteries, but it eliminates the need for temperature- and corrosion-resistant materials as well as for insulation.

According to Argonne, a typical vehicle with a 150-mile range would be equipped with a 42-kilowatt-hour battery, weighing about 900 pounds and containing 60 pounds of lithium. The current projection is for 18 million vehicles powered by lithium batteries to be on the road by the year 2000, requiring about 70 million pounds of new lithium annually, in addition to lithium recycled from scrapped batteries. Also, by the year 2000 as much as 3% of the projected domestic energy consumption may be supplied by lithium-sulfur offpeak energy-storage batteries, whose total lithium content may amount to a little over 1 billion pounds.

Still in the developmental stage is a fusion-type thermonuclear reactor that has been proposed as an alternative to the conventional fission reactor or to the controversial fast breeder reactor. The amount of lithium required in fusion reactors depends in part on the particular reactor design chosen. Reactors in which lithium is used both as a neutron-absorbing blanket around the reactor core and as a heat-transfer medium may require about 10 times as much lithium as designs in which it forms a blanket only. According to ERDA, between 200 and 2,000 pounds of lithium are required per megawatt of fusion capacity, and a large fusion power industry in the 21st century may thus require 200 million to 2 billion pounds of lithium.

Lithium batteries and fusion power, together with their potential impact on the lithium industry, were discussed at a symposium held in January 1976, at Golden, Colo. Proceedings of the symposium have since been published by the U.S. Geological Survey.[5]. A second symposium on lithium has been scheduled for October 1977, at Corning, N.Y.

The search for a less-energy-intensive method of aluminum production led to the revolutionary Alcoa Smelting Process, implemented at midyear in a newly built smelter in Palestine, Tex. Based on the electrolysis of aluminum chloride, to which minor amounts of lithium chloride and sodium chloride are added, the process is expected to reduce power requirements to 5 kilowatt-hours per pound of aluminum, compared with 6.5 kilowatt-hours per pound in today's most efficient conventional smelters. Although published data are as yet unavailable, it is understood that the process requires about 20 pounds of lithium chloride per ton of aluminum produced, and its impact on the lithium industry may be profound should it prove successful and be implemented in new smelters worldwide.

The feasibility of utilizing synthesized benzene and simple alkylated derivatives as nonpetrochemical gasoline components has been proposed.[6] Feasible raw materials include coal, coke, charcoal, and carbonaceous wastes. The basic synthesis consists of the formation of lithium carbide by reaction of the metal with carbon, hydrolysis of the carbide to acetylene, cyclization of acetylene to benzene and regeneration of lithium metal.

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[5]U.S. Geological Survey, Lithium Resources and Requirements by the Year 2000. Prof. Paper 1005, 1976, 162 pp.

[6]Tamers, M. A. Total Synthesis Benzene and Its Derivatives as Major Gasoline Extenders. Science, v. 193, No. 4249, July 16, 1976, pp. 231-233.

Magnesium

By Benjamin Petkof[1]

Domestic metal production was strong during the year but declined slightly from that of 1975. The recovery of secondary magnesium metal continued to increase. Total exports of magnesium declined in both quantity and value. Imports of all classifications of magnesium metal increased in both quantity and value. The quoted price of magnesium metal ingot increased $0.09 during the year. World primary production, excluding that of the United States, was slightly higher than that of 1975.

Legislation and Government Programs.—The General Services Administration strategic and critical stockpile contained 1,121 tons of magnesium at yearend. There was no stockpile goal for magnesium. During April 1976, 500 tons of magnesium metal were released from the stockpile. There were no accessions during the year.

Table 1.—Salient magnesium statistics

(Short tons)

	1972	1973	1974	1975	1976
United States:					
Production:					
Primary magnesium	120,823	122,431	W	W	W
Secondary magnesium	15,628	17,636	14,874	r27,873	30,553
Shipments: Primary	111,185	137,277	W	W	W
Exports	17,566	39,585	46,398	32,591	13,444
Imports for consumption	4,479	3,325	5,305	7,903	14,907
Consumption	103,691	115,774	130,048	r94,167	104,453
Price per pound cents	37.25	38.25	41.25-75.00	82.00	87.00-92.00
World: Primary production	257,529	r266,441	r [1]142,727	r [1]138,284	[1]148,094

rRevised. W Withheld to avoid disclosing individual company confidential data.
[1]Excludes United States production.

DOMESTIC PRODUCTION

Domestic production of magnesium metal ingot was strong in 1976 but was slightly below that of 1975. Publication of Bureau of Mines data on domestic production must be withheld to avoid disclosing individual company confidential data.

During the year, magnesium ingot was produced by American Magnesium Co., Snyder, Tex., with an annual production capacity of 10,000 short tons and The Dow Chemical Co., Freeport, Tex., with an annual production capacity of 120,000 short tons. NL Industries, Inc., halted magnesium production at its Rowley, Utah plant during the first quarter of 1976 in order to resolve technical and equipment problems. The company was expected to resume operations in 1977. Northwest Alloys, Inc., a wholly-owned subsidiary of Aluminum Co. of America (Alcoa), began magnesium ingot production during the first quarter of 1976 at its new plant near Addy, Wash. The

[1]Physical scientist, Division of Nonferrous Metals.

announced production capacity was 24,000 tons per year. All domestic magnesium producers except Northwest Alloys, Inc., used the electrolytic method; Northwest Alloys used the silicothermic process.

Secondary recovery of magnesium metal increased.

Table 2.—Magnesium recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1972	1973	1974	1975	1976
Kind of scrap:					
New scrap:					
Magnesium-base	6,993	7,417	3,357	4,076	2,838
Aluminum-base	5,646	6,118	5,798	r14,014	16,186
Total	12,639	13,535	9,155	r18,090	19,024
Old scrap:					
Magnesium-base	1,445	2,529	4,161	4,873	5,500
Aluminum-base	1,544	1,572	1,558	4,910	6,029
Total	2,989	4,101	5,719	9,783	11,529
Grand total	15,628	17,636	14,874	r27,873	30,553
Form of recovery:					
Magnesium alloy ingot[1]	3,612	2,606	2,703	2,796	3,569
Magnesium alloy castings (gross weight)	9	12	14	750	836
Magnesium alloy shapes	275	169	4	1,262	335
Aluminum alloys	8,790	9,206	9,316	r20,328	23,595
Zinc and other alloys	14	31	16	12	15
Chemical and other dissipative uses	794	567	44	44	28
Cathodic protection	2,134	5,045	2,777	2,681	2,175
Total	15,628	17,636	14,874	r27,873	30,553

rRevised.
[1]Includes secondary magnesium content of both secondary and primary alloy ingot.

CONSUMPTION AND USES

Total domestic consumption of primary magnesium in 1976 increased almost 11% over that of 1975 but did not reach the consumption level of 1974. Magnesium was consumed in structural products that included castings and wrought products, and in sacrificial purposes where advantage was taken of the metal's chemical and alloying properties. The metal's useful structural properties such as low specific weight, good machinability, hot formability, and high strength-to-weight ratio resulted in about 17% being used in aircraft, automotive, and other types of transportation equipment, materials handling equipment, and the manufacture of items such as power tools. The remainder was used for sacrificial purposes, primarily alloying with other metals, cathodic protection, production of nodular iron, and reducing agents for metals such as titanium, zirconium, uranium, and beryllium.

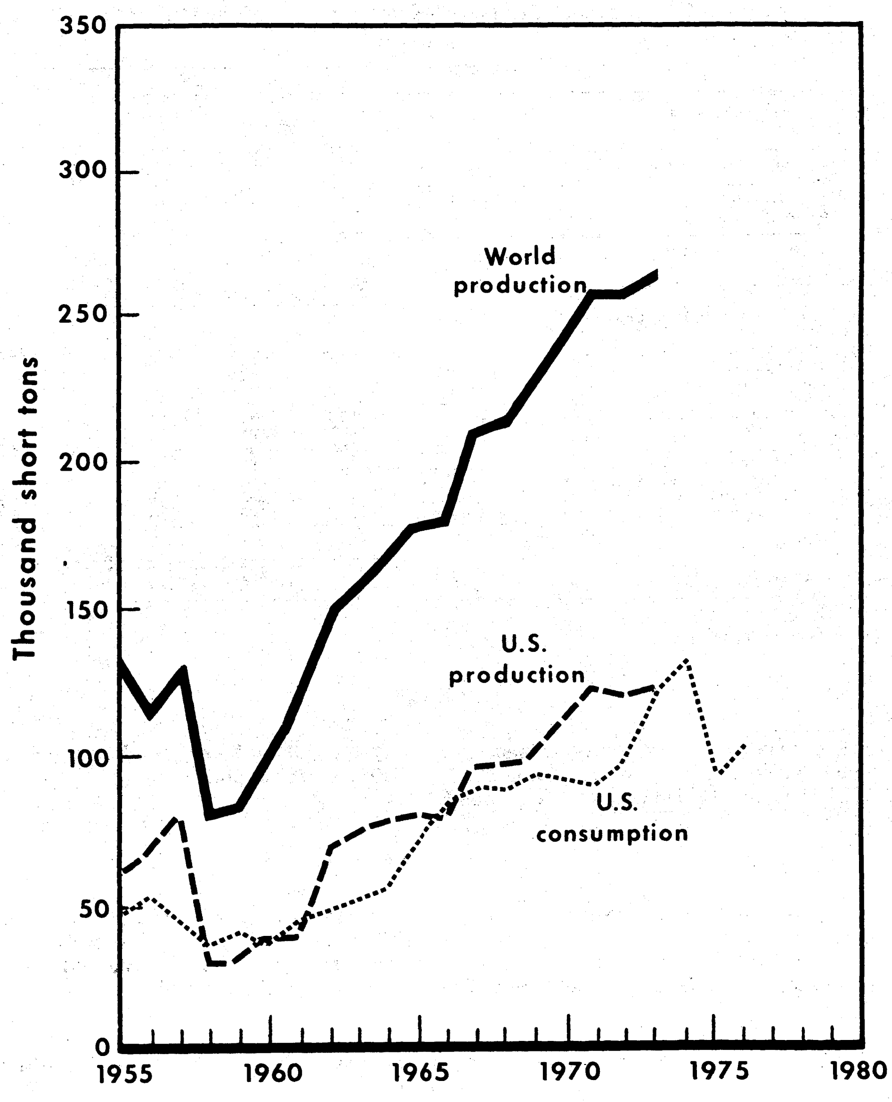

Figure 1.—U.S. and world production and U.S. consumption of primary magnesium.

Table 3.—Consumption of primary magnesium in the United States, by use

(Short tons)

	1972	1973	1974	1975	1976
For structural products:					
Castings:					
Die	9,326	9,999	11,804	r6,392	4,759
Permanent mold	736	812	1,000	r1,144	1,059
Sand	700	1,326	1,372	r1,952	1,233
Wrought products:					
Extrusions	7,749	7,436	7,323	r6,215	6,449
Sheet and plate	3,817	(1)	(1)	(1)	(1)
Other (includes forgings)	1,381	5,529	6,025	r3,451	3,792
Total	23,709	25,102	27,524	r19,154	17,292
For distributive or sacrificial purposes:					
Alloys:					
Aluminum	43,458	51,953	62,152	r46,670	54,320
Copper	38	503	19	13	14
Zinc	28	30	24	15	29
Other	109	13	16	11	10
Cathodic protection (anodes)	6,543	9,931	10,439	r4,702	7,809
Chemicals	9,732	9,835	9,204	2,592	3,385
Nodular iron	7,603	8,724	10,603	12,864	14,339
Scavenger and deoxidizer	327	50	285	(1)	(1)
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium	6,089	7,367	7,569	7,007	5,985
Other, including powder	6,055	2,266	2,213	1,139	1,270
Total	79,982	90,672	102,524	r75,013	87,161
Grand total	103,691	115,774	130,048	r94,167	104,453

rRevised.
[1]Included with "Other".

PRICES

The base price of magnesium ingot was increased during the year. As of January 1, 1976, the quoted price was: $0.87 per pound; July 1, 1976, $0.92 per pound; and January 1, 1977, $0.96 per pound.

STOCKS

Producer and consumer stocks of primary magnesium declined 12% to 17,295 tons at yearend 1976. Yearend stocks of primary magnesium alloy ingot dropped 35% to 988 tons. Stocks of primary metal at yearend 1975 were 19,664 tons and those of alloy ingot were 1,512 tons. New and old magnesium scrap stocks declined 34%.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1976

(Short tons)

Item	Stocks Jan.1r	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks Dec. 31
Cast scrap	714	6,922	623	6,044	6,667	969
Solid wrought scrap[1]	67	688	680	--	680	75
Total	781	7,610	1,303	6,044	7,347	1,044

rRevised.
[1]Includes borings, turnings, drosses, etc.

FOREIGN TRADE

Magnesium exports declined 59% from 32,591 tons in 1975 to 13,444 tons in 1976. The value also declined sharply from $48.2 million in 1975 to $26.9 million in 1976. Shipments to Brazil, West Germany, and Mexico represented 76% of the total. Most of the metal exported (91%) consisted of primary metals and alloys.

Total imports for consumption increased 89% from 7,903 tons valued at $11.5 million in 1975 to 14,907 tons valued at $22.7 million in 1976. Imports of metal accounted for 65% of total imports; waste and scrap, 23%; and alloys and other forms, 12%. Major sources of magnesium imports were: Norway (62%); Sweden (11%); and Canada (5%).

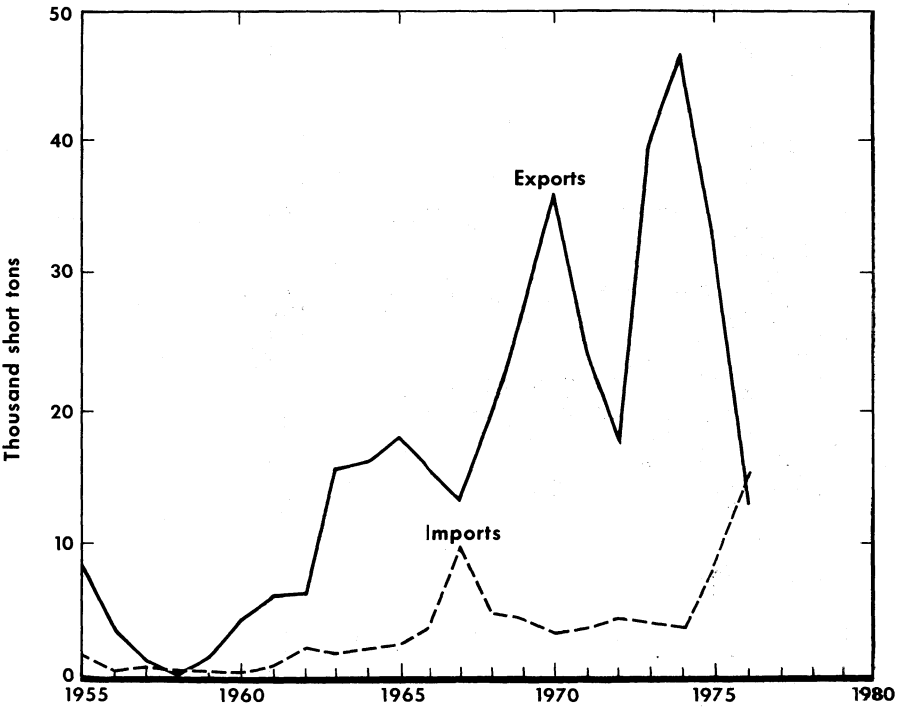

Figure 2.—U.S. imports and exports of magnesium.

Table 5.—U.S. exports of magnesium, by class and country

Destination	1975						1976					
	Waste and scrap		Primary metals, alloys		Semifabricated forms, n.e.c., including powder		Waste and scrap		Primary metals, alloys		Semifabricated forms, n.e.c., including powder	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	--	--	187	$322	1	$8	--	--	248	$476	11	$35
Australia	--	--	226	343	1	3	--	--	514	875	20	133
Austria	--	--	2	1	13	55	--	--	--	--	5	20
Belgium-Luxembourg	--	--	815	981	3	12	--	--	--	--	3	25
Brazil	29	$44	7,300	10,999	1	12	--	--	5,039	8,024	5	43
Canada	51	72	6,603	10,466	70	211	37	$52	786	1,167	190	1,281
Colombia	--	--	--	--	5	5	--	--	38	89	--	--
France	--	--	65	175	10	107	--	--	10	40	7	78
Germany, West	--	--	2,146	3,438	578	1,940	--	--	2,719	6,201	492	1,960
Ghana	--	--	115	197	--	--	--	--	--	--	2	5
India	--	--	102	157	--	--	--	--	112	146	--	--
Israel	--	--	6	36	--	--	8	56	([1])	5	29	93
Italy	--	--	63	189	22	112	--	--	97	344	25	72
Japan	9	8	4,964	6,329	226	642	20	19	193	539	143	447
Korea, Republic of	5	7	26	48	--	--	--	--	5	5	2	17
Mexico	22	81	1,372	2,197	56	94	--	--	1,851	3,050	75	164
Netherlands	--	--	6,418	7,379	7	26	--	--	5	15	14	65
Norway	--	--	--	--	1	20	--	--	--	--	1	9
South Africa, Republic of	--	--	329	600	6	69	--	--	159	265	4	27
Spain	--	--	10	16	20	58	--	--	30	53	19	46
Taiwan	360	91	15	17	([1])	1	--	--	26	37	7	13
United Kingdom	--	--	234	384	6	29	--	--	12	23	34	117
Venezuela	--	--	4	9	--	--	--	--	10	25	2	2
Other	--	--	45	109	42	92	1	3	363	574	71	167
Total	476	303	31,047	44,392	1,068	3,496	66	130	12,217	21,953	1,161	4,819

[1]Less than one-half unit.

Table 6.—U.S. exports and imports for consumption of magnesium

Year	Exports: Waste and scrap: Quantity (short tons)	Waste and scrap: Value (thousands)	Metals and alloys in crude form: Quantity (short tons)	Metals and alloys in crude form: Value (thousands)	Semifabricated forms n.e.c.: Quantity (short tons)	Semifabricated forms n.e.c.: Value (thousands)
1974	803	$365	44,440	$44,777	1,155	$3,369
1975	476	303	31,047	44,392	1,068	3,496
1976	66	130	12,217	21,953	1,161	4,819

Year	Imports: Waste and scrap: Quantity (short tons)	Waste and scrap: Value (thousands)	Metal: Quantity (short tons)	Metal: Value (thousands)	Alloys (magnesium content): Quantity (short tons)	Alloys (magnesium content): Value (thousands)	Powder, sheets tubing, ribbons wire, other forms (magnesium content): Quantity (short tons)	Powder, sheets tubing, ribbons wire, other forms (magnesium content): Value (thousands)
1974	4,320	$2,826	495	$692	440	$1,573	50	$135
1975	1,984	1,564	4,803	7,735	1,111	2,215	5	33
1976	3,376	2,997	9,690	16,023	1,820	3,604	21	38

WORLD REVIEW

World magnesium production, excluding that of the United States, increased 7% to 148,094 tons. The U.S.S.R. accounted for 47% of this total followed by Norway (29%); Japan (8%); France (6%). The remainder was supplied by Canada, the People's Republic of China, and Italy.

Canada.—In 1975 Canada imported 9,241 tons of magnesium and exported 4,152 tons of metal. Canadian aluminum alloy, casting, and other industries consumed 5,609 tons of metal in 1975.

Norway.—Norsk Hydro-Elektrisk A/S announced plans to build a new magnesium plant at Mongstad with an initial planned capacity of about 33,000 tons per year and an eventual capacity of 110,000 tons per year. Construction was expected to begin in 1978 with initial plant startup planned for 1981.

Table 7.—Magnesium: World production,[1] by country

(Short tons)

Country	1974	1975	1976[p]
Canada	[r]6,535	4,217	6,457
China, People's Republic of[e]	1,100	1,100	1,100
France	7,199	8,303	8,824
Italy	[r]8,191	6,993	[e]7,600
Japan[2]	9,836	9,412	12,335
Norway	43,866	42,259	42,778
U.S.S.R.[e]	66,000	66,000	69,000
United States	W	W	W
Total[3]	[r]142,727	138,284	148,094

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]Primary only.
[2]Secondary production was as follows, in short tons: 1974—11,990; 1975—10,171; and 1976—NA.
[3]Excludes United States production, which in previous years accounted for approximately 50% of the total.

TECHNOLOGY

Conditions for fluxless melting of magnesium metal in an air/sulfur hexafluoride atmosphere were described. Sulfur hexafluoride concentration levels to protect molten magnesium metal and alloy were determined to be a function of surface temperature and degree of surface agitation. The possible toxic effects of sulfur hexafluoride were also evaluated.[2]

A model was developed describing the rates of back reaction in a magnesia reduction cell. It was concluded that the chlorine dissolution rate was not the limiting factor in the back reaction between magnesium and chlorine in the electrolytic production of magnesium, flow of the molten bath in the cell was turbulent, transport of reactants to the reaction zone did not control the reaction; and small variations in the dispersion of magnesium metal droplets in the melt could increase the magnesium dissolution rate and cause significant current loss.[3]

A paper described the silico-thermic magnesium plant operated by the Société Française d' Electrométallurgie at Marignac, France.[4]

A new anodic electrolytic treatment for magnesium and its alloys that produces a protective coating superior and economically competitive with available commercial coating was described.[5]

Molten pig iron was desulfurized by injecting a mixture of lime and particulate magnesium metal or magnesium-aluminum alloy beneath the surface of sulfur containing pig iron. This process also avoided excessive slag buildup.[6]

A method for selective solution mining of magnesium chloride hexahydrate from an underground deposit of carnallite or bischofite was described. A low saturated monohydric aliphatic alcohol containing 1 to 4 carbon atoms per molecule was injected into the deposit to dissolve magnesium chloride hexahydrate. The solvent containing magnesium chloride hexahydrate was pumped to the surface for processing leaving a leached residue containing potassium chloride and sodium chloride. The magnesium chloride could be used in the production of magnesium metal. The remaining undissolved residue could be pumped or gaslifted to the surface for extraction of other mineral values.[7]

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[2]Couling, S. L., F. C. Bennett, and T. E. Leontis. Fluxless Melting of Magnesium. Proc. of Sessions, 106th AIME Ann. Meeting, Atlanta, Ga. Light Metals Committee, The Metallurgical Society of AIME, New York, v. 1, pp. 545-560.

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Magnesium Compounds

By Benjamin Petkof[1]

Austria, Greece, the U.S.S.R., the People's Republic of China, and North Korea continued to provide the major portion of world magnesite supply. Domestic production of almost all categories of magnesium compounds increased compared with 1975.

Exports of magnesite and magnesia totaled 81,494 short tons, a decline of 11% from those of 1975. Imports of processed magnesite declined sharply from those of 1975.

Table 1.—Salient magnesium compound statistics

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Caustic-calcined and specified magnesias:[1]					
Shipments by producers:					
Quantity	128	158	149	120	134
Value	15,856	26,929	27,916	17,207	28,277
Exports: Value[2]	3,377	4,196	5,088	4,538	5,422
Imports for consumption: Value[2]	675	734	692	502	808
Refractory magnesia:					
Sold and used by producers:					
Quantity	696	807	803	709	768
Value	60,331	69,904	77,044	103,839	106,522
Exports: Value	5,903	6,104	7,749	14,146	13,466
Imports: Value	9,300	13,469	16,463	20,588	13,976
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	1,075	1,250	1,277	914	1,007
Value	20,158	23,441	32,078	31,193	37,079
World: Crude magnesite production:					
Quantity	9,884	10,162	r11,097	r11,147	10,598

[1]Excludes caustic-calcined magnesia used in production of refractory magnesia.
[2]Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

Magnesium compounds were produced primarily from some type of natural brine solution. Natural magnesite and olivine were produced only at a few operations in the United States.

Barcroft Co.; The Dow Chemical Co.; Harbison-Walker Refractories Co.; Kaiser Aluminum & Chemical Corp.; Merck & Co., Inc.; and Michigan Chemical Corp., produced magnesium hydroxide from seawater and well brines. This magnesium compound was used primarily to produce magnesia for the manufacture of basic refractories. Refractory magnesia was produced by Basic, Inc.; Basic Magnesia, Inc.; Corhart Refractories Co., Inc.; A. P. Green Refractories Co.; Harbison-Walker Refractories Co.; Kaiser Aluminum & Chemical Corp.; and Martin-Marietta Chemicals. Total production of refractory magnesia in 1976 was 727,622 tons.

[1]Physical scientist, Division of Nonferrous Metals.

Total 1976 production of caustic-calcined magnesia was 160,364 tons. Producers of caustic-calcined magnesia were Basic, Inc.; Basic Magnesia, Inc.; The Dow Chemical Co.; Kaiser Aluminum & Chemical Corp.; Martin Marietta Chemicals; and Michigan Chemical Corp. Merck & Co., Inc.; Michigan Chemical Corp.; and Morton Chemical Co.; produced 15,236 tons of specified magnesia. The Dow Chemical Co., Mallinckrodt Chemical Works, and Philadelphia Quartz Co., produced magnesium sulfate. Magnesium carbonate was produced by Mallinckrodt Chemical Works; Merck & Co., Inc.; Michigan Chemical Corp.; and Morton Chemical Co.

Magnesium chloride was produced by American Magnesium Co., The Dow Chemical Co., Western Magnesium Corp. (formerly FMC Corp., plant facilities sold to Western Magnesium Corp., March 1976), Great Salt Lake Minerals & Chemicals Corp., and Kaiser Aluminum & Chemical Corp. Magnesium chloride was used primarily to produce magnesium metal. Domestic producers of magnesium compounds by raw material source, location, and capacity follow:

Raw material source and producing company	Location	Capacity (short tons of MgO equivalent)
Magnesite: Basic, Inc	Gabbs, Nev	150,000
Lake brines:		
Great Salt Lake Minerals & Chemicals Corp	Ogden, Utah	100,000
Kaiser Aluminum & Chemical Corp	Wendover, Utah	50,000
Well brines:		
The Dow Chemical Co	Ludington, Mich	250,000
Martin Marietta Chemicals	Manistee, Mich	280,000
Michigan Chemical Corp	St. Louis, Mich	25,000
Morton Chemical Co	Manistee, Mich	5,000
Seawater:		
Barcroft Co	Lewes, Del	5,000
Basic Magnesia, Inc	Port St. Joe, Fla	100,000
Corhart Refractories Co	Pascagoula, Miss	40,000
The Dow Chemical Co	Freeport, Tex	100,000
Harbison-Walker Refractories Co	Cape May, N.J	100,000
Kaiser Aluminum & Chemical Corp	Moss Landing, Calif	150,000
Merck & Co., Inc	South San Francisco, Calif	10,000
Western Magnesium Corp	Chula Vista, Calif	5,000
Total		1,370,000

CONSUMPTION AND USES

Domestic use of almost all magnesium compounds increased in 1976, a reversal from the pattern of 1975. Refractories manufacture continued to be the major end use for magnesia. Refractory magnesia consumption increased 8% in quantity and 3% in value over 1975. Consumption of caustic-calcined and specified magnesias increased 12% in quantity and 64% in value, magnesium hydroxide increased only slightly in quantity but 44% in value, and magnesium sulfate increased 18% in quantity and 54% in value. Magnesium carbonate consumption decreased 21% in quantity and 7% in value.

The quantity of caustic-calcined and specified magnesias used to prepare agricultural, nutritional, and pharmaceutical products increased 13%; construction materials decreased 36%; and chemical processing, manufacturing, and metallurgical increased 22%.

Magnesia had a broad area of use including the production of animal feed, fertilizers and pharmaceuticals, and other chemical processing and manufacturing applications.

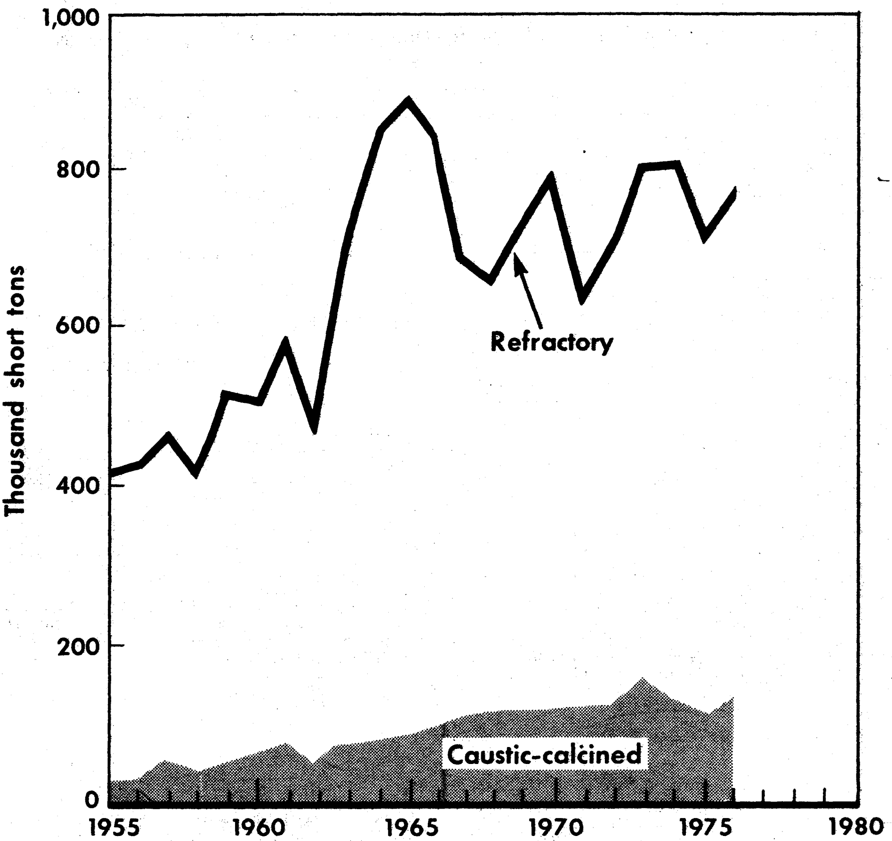

Figure 1.—Consumption and shipments of magnesia in the United States.

Table 2.—Magnesium compounds shipped and used in the United States

	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Caustic-calcined[1] and specified (USP and technical) magnesias	119,551	$17,207	134,458	$28,277
Refractory magnesia	709,474	103,839	767,607	106,522
Magnesium hydroxide (100% $Mg(OH)_2$)[1]	60,344	5,410	61,059	7,784
Magnesium sulfate (anhydrous and hydrous)	47,458	6,406	55,993	9,835
Precipitated magnesium carbonate[1]	6,982	1,605	5,535	1,496

[1]Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.

Table 3.—Domestic shipments of caustic-calcined and specified magnesias, by use

(Short tons)

Use	1975	1976
Agriculture, nutrition, and pharmaceuticals:		
Animal feed	23,371	29,859
Fertilizer	7,840	7,695
Medicinals and pharmaceuticals	2,186	2,548
Sugar and candy	W	W
Winemaking	W	W
Total	39,229	44,393
Construction materials:		
Insulation and wallboard	(1)	(1)
Oxychloride and oxysulfate cement	18,456	11,797
Total	18,456	11,797
Chemical processing, manufacturing, and metallurgical:		
Chemical	7,481	10,051
Electrical heating rods	8,179	11,629
Flux	W	W
Petroleum additive	8,890	10,955
Pulp and paper	12,799	12,997
Rayon	10,989	10,095
Rubber	7,315	12,103
Stack gas scrubbing	W	--
Uranium processing	W	W
Water treatment	2,258	5,688
Total	61,866	75,418
Unspecified uses	--	2,850
Grand total	119,551	134,458

W Withheld to avoid disclosing individual company confidential data; included with "Total."
[1]Included with "Oxychloride and oxysulfate cement."

PRICES

The prices for magnesia, natural, technical, heavy, 85% and 90% (bulk, carlot and truckload, f.o.b. Luning, Nev.) were quoted at yearend at $120 and $140 per short ton, respectively, according to the Chemical Marketing Reporter. Magnesia, technical, neoprene-grade, light, was quoted at $346 per ton (bags, carlot and truckload, works).

Prices throughout 1976 for magnesium carbonate, technical (bags, carlot, freight-equalized) were quoted at $0.22 to $0.23 per pound, and NF-grade, $0.30 to $0.31 per pound. During the year, the price for magnesium hydroxide, NF, powder, (drums, carlot and truckload, works) was $0.35 to $0.36 per pound. Magnesium chloride, hydrous, 99%, flakes (bags, carlot, works) was quoted at $140 per ton at yearend.

The price for magnesium sulfate, technical (bags, mixed carlot, 10,000-pound minimum, works) was quoted at $0.09 per pound at yearend. In bulk lots it was $0.085 per pound.

FOREIGN TRADE

Dead-burned magnesite and magnesia exports declined 14% in quantity and 5% in value from those of 1975. Shipments to major countries decreased significantly during the year. Canada received 59% of total exports; West Germany, 24%; and Mexico, 5%.

Magnesite exports including crude, caustic-calcined, lump or ground, declined 11% in quantity and 19% in value from those of 1975. Shipments to Canada, Venezuela, Australia, West Germany, and Mexico accounted for 66% of exports in this category.

Imports of lump, ground and caustic-calcined magnesia increased 43% in quantity to 8,194 tons and 61% in value in 1976. Most of the imports were from India (66%), Australia (18%), and Turkey (11%). Imports of dead-burned and grain magnesia and periclase containing a maximum of 4% lime decreased 34% from 125,540 tons in 1975 to 82,676 tons in 1976. Imports of this category have declined annually since 1973. Imports of the same material, but containing over 4% lime, declined 83% in quantity and 87% in value to 5,359 tons and $542,000, respectively. Total imports of crude and processed magnesite declined 41% from 162,048 tons in 1975 to 96,229 tons in 1976.

Imports of specified magnesium compounds and compounds not specifically provided for were valued at $2,266,000, an increase of 26% over that of 1975.

Table 4.—U.S. exports of magnesite and magnesia, by country

Destination	Magnesite and magnesia, dead-burned				Magnesite, n.e.c., including crude caustic-calcined, lump or ground			
	1975		1976		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	--	--	3,319	$582	51	$36	60	$46
Australia	225	$34	--	--	216	170	731	624
Austria	4,473	r76	754	171	--	--	6	4
Belgium-Luxembourg	--	--	--	--	31	17	46	29
Brazil	51	41	93	94	80	50	112	81
Canada	48,438	6,970	42,043	7,038	2,470	1,118	3,036	1,292
Chile	1,729	309	294	54	9	6	52	25
Colombia	1	(1)	29	14	77	48	54	43
Denmark	11	2	22	7	--	--	--	--
Finland	17	5	--	--	48	32	78	62
France	20	3	983	177	271	168	343	282
Germany, West	14,499	3,172	17,085	3,675	r654	461	667	465
Israel	--	--	--	--	28	18	22	15
Italy	1,200	230	--	--	263	135	395	225
Japan	15	12	33	24	36	34	85	155
Korea, Republic of	--	--	--	--	7	5	9	8
Mexico	7,609	1,141	3,544	461	14	9	635	94
Netherlands	15	4	15	4	961	756	261	185
Netherlands-Antilles	4	1	4	2	65	9	--	--
New Zealand	16	15	16	15	36	32	133	127
Peru	--	--	--	--	26	14	23	21
Philippines	102	37	144	49	20	12	44	36
South Africa, Republic of	3,265	891	183	180	154	92	172	86
Spain	18	9	3	3	62	41	273	48
Sweden	44	42	22	23	343	289	357	380
Switzerland	16	5	--	--	2	1	--	--
Taiwan	--	--	--	--	24	10	41	25
U.S.S.R.	--	--	--	--	--	--	--	--
United Kingdom	767	418	478	401	449	281	496	380
Venezuela	--	--	--	--	253	78	1,586	517
Yugoslavia	--	--	--	--	2,291	523	23	21
Other	119	r729	2,309	492	r157	93	381	146
Total	82,654	14,146	71,373	13,466	9,098	4,538	10,121	5,422

rRevised.
1Less than 1/2 unit.

Table 5.—U.S. imports for consumption of crude and processed magnesite, by country

Country	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Lump or ground caustic-calcined magnesia:[1]				
Australia	692	$102	1,501	$228
Canada	--	--	7	2
India	4,298	286	5,427	406
Japan	2	8	175	20
Netherlands	167	24	203	27
Sweden	6	2	--	--
Turkey	551	80	881	125
Total	5,716	502	8,194	808
Dead-burned and grain magnesia and periclase:				
Not containing lime or not over 4% lime:				
Australia	607	84	--	--
Austria	2,200	280	3,373	394
Canada	67	13	231	4
China, People's Republic of	784	114	--	--
Cyprus	1,763	236	--	--
Finland	1,694	215	--	--
France	(2)	1	--	--
Greece	68,844	11,713	33,094	5,638
Ireland	40,756	6,759	42,662	7,368
Japan	1,653	214	3,316	572
Turkey	224	33	--	--
United Kingdom	4,739	687	--	--
Yugoslavia	2,209	239	--	--
Total	125,540	20,588	82,676	13,976
Containing over 4% lime:				
Austria	6,185	814	--	--
Canada	900	50	410	47
Germany, West	--	--	1	2
Greece	9,290	1,240	--	--
Spain	2,752	385	4,948	493
United Kingdom	1,870	209	--	--
Yugoslavia	9,795	1,382	--	--
Total	30,792	4,080	5,359	542
Total dead-burned and grain magnesia and periclase	156,332	24,668	88,035	14,518

[1]In addition, crude magnesite was imported as follows: 1975—India, 7 short tons ($577), the United Kingdom, 3 short tons ($280); 1976—India, 5 short tons ($456), Japan, 10 short tons ($590), Mexico, 2 short tons ($519), and the United Kingdom, 3 short tons ($376).
[2]Less than 1/2 unit.

Table 6.—U.S. imports for consumption of magnesium compounds

Year	Oxide or calcined magnesia Quantity (short tons)	Oxide or calcined magnesia Value (thousands)	Magnesium carbonate[1] (precipitated) Quantity (short tons)	Magnesium carbonate[1] (precipitated) Value (thousands)	Magnesium chloride (anhydrous) Quantity (short tons)	Magnesium chloride (anhydrous) Value (thousands)	Magnesium chloride (other) Quantity (short tons)	Magnesium chloride (other) Value (thousands)	Magnesium sulfate (epsom salts and kieserite) Quantity (short tons)	Magnesium sulfate (epsom salts and kieserite) Value (thousands)	Magnesium salts and compounds n.s.p.f.[2] Quantity (short tons)	Magnesium salts and compounds n.s.p.f.[2] Value (thousands)
1974	357	$231	117	$109	309	$190	244	$12	25,644	$702	5,393	$863
1975	360	148	63	97	103	42	50	9	32,991	1,070	2,999	427
1976	299	332	80	108	217	158	428	108	23,139	1,109	2,874	451

[1]In addition, magnesium carbonate not precipitated, was imported in 1974—19 short tons ($6,961); 1975—6 short tons ($2,226); 1976—2 short tons ($915).
[2]Not specifically provided for; includes magnesium silicofluoride or fluosilicate and calcined magnesium.

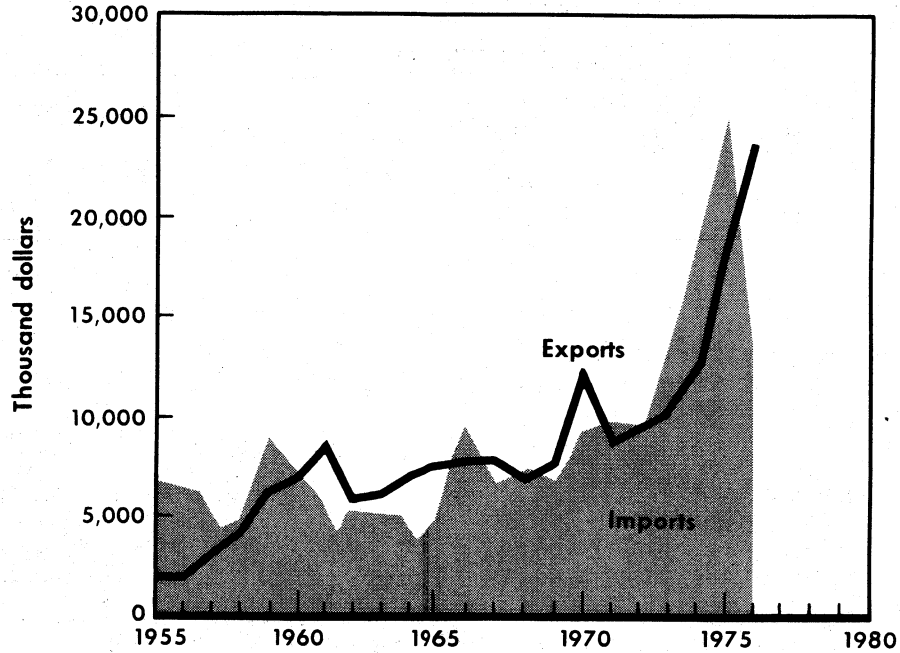

Figure 2.—Value of U.S. exports and imports of magnesia.

WORLD REVIEW

Greece.—In October 1976, the Financial Mining-Industrial & Shipping Corp. (FIMISCO) of the Scalistiri Group began tests at its pilot plant at Mantoudi, Euboea for its proposed $50 million plant for the production of refractory-grade magnesia from seawater and dolomite. Harbison-Walker Refractories International (a division of Dresser Industries, Inc.) will provide technical assistance for this project. Ten percent of investment costs were budgeted for environmental protection.

Near the end of 1976, FIMISCO began production of Magflot, a briquetted deadburned magnesite produced from processed low-grade magnesite and wastes by proprietary technology. This new $10 million 50,000 ton-per-year-plant at Mantoudi, has a flotation plant, a Herreshoff and shaft kiln, and a briquetting press.

The Macedonian Magnesite Mining-Industrial and Shipping Corp., another Scalistiri Group company, received Government approval to expand and improve magnesite mining and shiploading facilities at Ormilia, Chalkidiki. Authorization was also received for construction of a deadburned magnesite briquetting plant similar to FIMISCO's operation.

Magnomin General Mining Co., S.A., a General Refractories' subsidiary, began operation of ore beneficiating facilities in Chalkidiki using Belgian-Yugoslav technology for preparing magnesite ore and tailings.

India.—The Government placed an export ban on calcined magnesite containing less than 9% silica. However, magnesite containing more than 9% silica remained exportable to all countries. According to Government sources the ban was prompted by an increasing domestic demand for magnesite.

The Indian Mineral Exploration Corp., delineated areas containing magnesite deposits. The Dewalthal deposit near the town of Pithoragarh was selected for initial development with a planned initial capacity of 15,000 tons per year. Almora Magnesite Ltd., owned by Tata Iron & Steel Co., Ltd., and Didier-werke of West Germany opened a dead-burned magnesite plant at Almora in 1975.

Table 7.—Magnesite: World production by country[1]

(Short tons)

Country	1974	1975	1976[p]
North America:			
Mexico	24,390	43,567	25,558
United States	W	W	W
South America:			
Brazil	403,072	484,428	461,868
Colombia[e]	2,000	2,000	2,200
Europe:			
Austria	1,597,385	1,395,358	1,021,334
Czechoslovakia	698,865	729,729	718,706
Greece	1,508,818	1,572,032	1,653,520
Poland	26,235	29,597	28,219
Spain	292,454	377,034	330,693
U.S.S.R.[e]	[r]1,920,000	1,980,000	1,980,000
Yugoslavia	510,932	534,952	431,003
Africa:			
Kenya	[e]11,000	18,519	[e]18,700
Rhodesia, Southern[e]	22,000	22,000	22,000
South Africa, Republic of	115,317	67,464	69,289
Sudan[e]	110	110	110
Tanzania[e]	55	55	55
Asia:			
China, People's Republic of[e]	1,100,000	1,100,000	1,100,000
India	292,699	345,480	361,476
Iran[e 2]	17,600	17,600	5,500
Korea, North[e]	1,900,000	1,900,000	1,900,000
Pakistan	3,163	2,864	3,854
Turkey	629,162	505,816	447,539
Oceania:			
Australia	[r]21,275	17,866	[e]15,400
New Zealand	911	872	887
Total	[r]11,097,443	11,147,343	10,597,911

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]Figures represent crude salable magnesite. In addition to the countries listed, Bulgaria and Canada produce magnesite, but output is not reported and available information is inadequate to make reliable estimates of output levels.
[2]Year beginning March 21 of that stated.

TECHNOLOGY

The Bureau of Mines developed a specially formulated magnesium oxysulphate cement for use as a sealant in underground coal mines. The cement was designed to reduce sloughing of shale roofs and coal ribs, to reduce air losses through block stoppings, for constructing sprayed stoppings over jute cloth or metal lath, and to decrease combustibility of polyurethane foam. The cement was evaluated underground.[2]

Blast furnace operation was improved by the addition of 1% to 2% crushed olivine to a charge containing a high alkali metal oxide content. The addition of the olivine removed a substantial part of the alkali metal oxides. The olivine was included in the ore briquettes, fine iron oxides, coke, or other charge materials.[3]

Samples of commercial burned magnesite refractories, as well as specially prepared samples of magnesite were studied to determine fracture energies. It was noted that the factors of temperature, chemistry, and microstructure significantly affected the fracture energies of these materials. The experimental results indicated that control of the coarse grain size distribution can be used to prepare refractories with improved fracture and thermal shock resistance.[4]

[2]Fraley, J. E., and R. E. Simpson. Magnesium Oxysulfate Cement Sealant in Coal Mines. BuMines RI 8150, 1976, 17 pp.

[3]Ellenbaum, F. H., and R. Ciesco. (assigned to Molten Metal Engineering Co.). Use of Olivine in Blast Furnace Smelting of Iron Oxide Ore. U.S. Pat. 3,966,456, June 29, 1976.

[4]Uchno, J. J., R. C. Beadt, and D. P. H. Nasselman. Fracture Surface Energies of Magnesite Refractories. Am. Ceram. Soc. Bull., v. 55, No. 7, July 1976, pp. 665-668.

Manganese

By Gilbert L. DeHuff[1]

There was neither production nor shipments of manganese ore containing 35% or more manganese in the United States in 1976. Production of ferromanganese fell off in the second half of 1976, while imports of the alloy exceeded the high level of 1975 and were the highest on record. Imports of manganese metal were high, coming mostly from the Republic of South Africa. The price for imported standard high-carbon ferromanganese fell during the year to levels considerably below the published producer price, which remained unchanged at $425 per long ton after a $15 drop early in January. Overall consumption of manganese increased over that of 1975. The General Services Administration (GSA) established new stockpile goals for manganese ores, alloys, and metal, but these were later suspended by the new administration. There were few sales of Government manganese stockpile excesses, but deliveries continued to be made in fulfillment of earlier sales contracts. These were mostly of ore.

Legislation and Government Programs.—On October 1, GSA established new stockpile goals for manganese. These are listed here in short tons, gross weight, with the immediately previous objectives shown in parentheses: Natural battery ore, 12,736 (10,700); synthetic dioxide, 19,105 (zero); chemical ore (no longer broken down into two types), 247,136 (25,600 equally divided between types A and B); metallurgical ore, 2,052,000 (750,500); high-carbon ferromanganese, 439,000 (200,000); medium-carbon ferromanganese, 99,000 (10,500); silicomanganese, 81,000 (15,900); and electrolytic metal, 15,000 (4,750). These goals were suspended by the new administration early in 1977 pending further study.

Sales of Government manganese stockpile excesses for the calendar year, as reported by GSA, were as follows in short tons (gross weight): Natural battery ore of stockpile grade, 123; synthetic dioxide, 545; chemical ore, 1,000 of type A and 6,000 of type B; metallurgical ore, 20,613 of stockpile grade and 22,047 of nonstockpile grade.

Government stockpile physical inventory changes for manganese items in calendar year 1976, all decreases, consisted of the following (short tons, gross weight): Stockpile-grade natural battery ore dropped 1,631 tons to 250,441 tons; synthetic dioxide,

[1]Supervisory physical scientist, Division of Ferrous Metals.

Table 1.—Salient manganese statistics in the United States

(Short tons)

	1972	1973	1974	1975	1976
Manganese ore (35% or more Mn):					
Production (shipments)	578	239	--	--	--
Imports, general	1,620,252	1,509,793	1,225,033	1,574,045	1,316,812
Consumption	2,331,459	2,140,058	1,880,176	1,818,983	1,600,873
Manganiferous ore (5% to 35% Mn):					
Production (shipments)	147,161	203,055	272,908	r159,225	256,633
Ferromanganese:					
Production	800,723	683,075	544,361	575,809	482,662
Exports	6,842	8,574	7,011	32,300	6,789
Imports for consumption	348,539	390,591	421,222	397,212	537,409
Consumption	967,968	1,116,602	1,115,395	881,527	896,775

rRevised.

2,832 to 3,006 tons; chemical ore, 10,770 to 230,863 tons; metallurgical ore, stockpile grade, 644,884 to 4,969,528 tons; metallurgical ore, nonstockpile grade, 21,686 to 1,319,030 tons; and high-carbon ferromanganese, 7,721 to 599,757 tons. Stocks of nonstockpile-grade natural battery ore remained unchanged at 54,899 tons; medium-carbon ferromanganese at 28,920 tons; silicomanganese at 23,574 tons; and electrolytic manganese metal at 14,171 tons.

In May, the Environmental Protection Agency issued national air pollution control regulations for electric submerged arc furnaces and associated dust-handling equipment, construction or modification of which began after October 21, 1974. For such furnaces producing manganese ferroalloys, particulate emissions to the atmosphere were limited by these regulations to less than 0.51 pound per megawatt-hour.

The National Stockpile Purchase Specification for Manganese Metal, Electrolytic, was revised June 9, 1976 (P-98-R3) by the Bureau of Domestic Commerce, U.S. Department of Commerce, with approval of the Federal Preparedness Agency, GSA. It specified the minimum manganese content by weight as 99.9% total, 99.7% metallic; decreased maximum hydrogen from 0.015% to 0.010%; increased maximum sulfur from 0.024% to 0.030%; and decreased maximum carbon and phosphorus from 0.01% and 0.005% to 0.005% and 0.001%, respectively.

DOMESTIC PRODUCTION

There was neither production nor shipments of manganese ore, concentrate, or nodules, containing 35% or more manganese, in the United States. Ferruginous manganese ores or concentrates containing 10% to 35% manganese were produced and shipped in the Cuyuna Range of Minnesota, and manganiferous iron ore containing 5% to 10% manganese was produced and shipped in New Mexico. Manganiferous schist, clay, or other earthy material, associated with the manganiferous member of the Battleground schist of the Kings Mountain area, was mined in Cherokee County, S.C., by brick manufacturers or contractors for use in coloring brick at South and North Carolina brick plants. Material from some pits had a manganese content greater than 5% and less than 10%, or possibly 15% at the most, whereas material from others contained less than 5% manganese. Because few operators analyze the material, the quantity that might contain 5% or more manganese can only be estimated. The total such quantity mined in 1976 appears to have been about 9,000 tons.

Table 2.—Manganese and manganiferous ore shipped[1] in the United States, by State

(Short tons)

Type and State	1975 Gross weight	1975 Manganese content	1976 Gross weight	1976 Manganese content
Manganese ore (35% or more Mn, natural)	--	--	--	--
Manganiferous ore:				
Ferruginous manganese ore (10% to 35% Mn, natural):				
Minnesota	108,749	12,880	202,271	25,891
New Mexico	49,976	5,696	--	--
Total	158,725	18,576	202,271	25,891
Manganiferous iron ore (5% to 10% Mn, natural):				
New Mexico	--	--	45,362	4,445
South Carolina[2]	r e500	r e35	e9,000	e660
Total	r e500	r e35	54,362	5,105
Total manganiferous ore	r159,225	r18,611	256,633	30,996
Value of manganese and manganiferous ore	r$1,412,912	--	$2,260,209	--

eEstimate. rRevised.

[1]Shipments are used as the measure of manganese production for compiling U.S. mineral production value. They are taken at the point at which the material is considered to be in marketable form for the consumer. Besides direct-shipping ore, they include, without duplication, concentrate and nodules made from domestic ores.

[2]Miscellaneous ore.

CONSUMPTION, USES, AND STOCKS

In the production of raw steel (ingots, continuous- or pressure-cast blooms, billets, slabs, etc., and including steel castings), consumption of manganese as ferroalloys, metal, and direct-charged ore, as reported to the Bureau of Mines by consumers, was 12.2 pounds per short ton of raw steel produced. Of this total, 10.6 pounds was ferromanganese; 1.4 pounds, silicomanganese; 0.01 pound, spiegeleisen; 0.2 pound, metal; and 0.01 pound, manganese ore (containing 35% or more manganese). The comparable 1975 total, on the same basis, was 13.3 pounds with ferromanganese at 11.4, silicomanganese at 1.6, spiegeleisen at 0.03, metal at 0.2, and ore at 0.02. In addition to the aforementioned consumption of manganese in 1976, there was consumed per ton of raw steel produced approximately 1.0 pound of manganese contained in manganese ore used in making pig iron or equivalent hot metal. The comparable figures for 1975, 1974, and 1973 were 1.3, 1.2, and 1.1 pounds, respectively.

Producers of manganese ferroalloys and metal were beset with problems of rising transportation, labor, raw material, pollution control, and energy costs; availability of sufficient energy without interruption; general inflation; a deluge of imports at low prices; and a demand that fell short of expectations because of a poor second half year for the steel industry.

Electrolytic Manganese Metal.—All of the manganese metal produced domestically, and virtually all of that imported, was electrolytic metal. Virtually all of the metal consumed was electrolytic metal, although some low-carbon ferromanganese (such as the domestically produced "Massive Manganese" or the imported "Gimel Metal") and some manganese-aluminum additives may have been erroneously reported by consumers as manganese metal. The metal that was used to make manganese-aluminum additives is included in table 4 under the "Alloys (excludes alloy steels and superalloys)" category. These additives are not knowingly included in the table, it being desired to report consumption at the metal rather than the additive level of the usage cycle.

Production of electrolytic manganese metal increased to 23,966 short tons from 22,141 tons in 1975. Production was by the same three plants of the same three companies: Foote Mineral Co., New Johnsonville, Tenn.; Kerr-McGee Chemical Corp., Hamilton (Aberdeen), Miss.; and Union Carbide Corp., Marietta, Ohio. Newmont Mining Corp.'s interest in Foote Mineral Co. was 90.6%.

Ferromanganese.—Bethlehem Steel Corp., at Johnstown, Pa., and United States Steel Corp., at McKeesport, Pa., were the only domestic blast furnace ferromanganese producers. U.S. Steel stopped production in March and Bethlehem had its ferromanganese furnace on pig iron for part of the year. As in 1975, electric furnaces were used to produce ferromanganese by six companies in eight plants: Airco Alloys Div., Airco Inc., Calvert City, Ky.; Ohio Ferro-Alloys Corp., Philo, Ohio; Roane Electric Furnace Co. (Engelhard Minerals & Chemicals Corp.), Rockwood, Tenn.; Satral-

Table 3.—Consumption and industry stocks of manganese ore[1] in the United States

(Short tons)

	Consumption 1975	Consumption 1976	Stocks Dec. 31, 1976
By use:			
Manganese alloys and metal	1,440,243	1,263,531	1,766,524
Pig iron and steel	176,167	143,761	142,130
Dry cells, chemicals and miscellaneous	202,573	193,581	346,988
Total	1,818,983	1,600,873	2,255,642
By origin:			
Domestic	75,755	81,607	179,919
Foreign	1,743,228	1,519,266	2,075,723
Total	1,818,983	1,600,873	2,255,642

[1]Containing 35% or more manganese (natural).

Table 4.—Consumption, by end use, and industry stocks of manganese ferroalloys and metal in the United States in 1976

(Short tons, gross weight)

End use	Ferromanganese: High carbon	Ferromanganese: Medium and low carbon	Silico-manganese	Spiegel-eisen	Man-ganese metal[1]
Steel:					
Carbon	601,421	104,428	87,888	4,107	7,236
Stainless and heat resisting	7,230	1,905	7,737	--	5,838
Full alloy	77,500	20,918	27,222	323	1,027
High-strength low-alloy	45,547	9,061	7,160	--	617
Electric	187	146	570	--	17
Tool	1,777	228	29	--	533
Unspecified	397	327	2,962	--	--
Total steel	734,059	137,013	133,568	4,430	15,268
Cast irons	16,789	1,296	16,006	4,960	134
Superalloys	249	W	W	--	316
Alloys (excludes alloy steels and superalloys)	4,277	1,772	3,003	22	11,365
Miscellaneous and unspecified	375	945	1,951	--	1,043
Total consumption	755,749	141,026	154,528	9,412	28,126
Stocks, Dec. 31:					
Consumer	169,313	20,482	23,999	W	4,370
Producer	86,918	25,765	38,129	W	7,173
Total stocks	256,231	46,247	62,128	8,066	11,543

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified" where applicable.

[1]Virtually all electrolytic.

Table 5.—Ferromanganese and silicomanganese produced in the United States and manganese ore[1] consumed in their manufacture

Year	Production: Ferromanganese: Gross weight (short tons)	Ferromanganese: Manganese content: Percent	Ferromanganese: Manganese content: Short tons	Silico-manganese (gross weight short tons)	Manganese ore[1] consumed (gross weight, short tons): Foreign[2]	Domestic[2]	Per ton of ferromanganese made[3]	Per ton of ferromanganese and silicomanganese made[3 4]
1972	800,723	78.3	627,358	153,000	1,896,483	25,620	2.3	2.0
1973	683,075	78.8	538,119	184,000	1,648,806	25,912	2.4	1.9
1974	544,361	78.0	424,405	196,000	1,348,425	55,822	2.5	1.8
1975	575,809	78.9	454,309	143,000	1,389,300	48,011	2.4	1.9
1976	482,662	79.0	381,328	129,000	1,208,336	53,632	2.5	2.0

[1]Containing 35% or more manganese (natural).
[2]Includes ore used in producing silicomanganese and metal.
[3]Includes ore used in producing silicomanganese.
[4]Ratio of ore consumed to ferromanganese produced if silicomanganese is considered a special grade of ferromanganese.

loy Inc. Div., Satra Corp., Steubenville, Ohio; Tenn-Tex Alloy Corp. of Houston, Houston, Tex.; and Union Carbide Corp., Alloy, W.Va., Marietta, Ohio, and Portland, Oreg. Fused-salt electrolysis continued to be used by Chemetals Div., Diamond Shamrock Corp., Kingwood, W.Va., to make low-carbon ferromanganese sold under the trade name of Massive Manganese. Doubling of plant capacity to 17,000 short tons of product per year was completed. Tenn-Tex Alloy Corp. of Houston, a subsidiary of Sandgate Corp., continued to operate under a 6-year lease agreement that provided for all production to go to Union Carbide Corp. U.S. shipments of ferromanganese from furnaces totaled 494,000 tons, compared with 556,000 tons in 1975.

The production reported in the various tables of this chapter is net production; that is, the quantity of ferromanganese produced for shipment outside the producing ferroalloy facility. It does not include the remelt material; that is, the fines, offgrade, or other ferromanganese output of the furnace that was fed back to the furnace or lost in the plant, and which is included in gross data reported by the furnace operator. It does include ferromanganese made for use in the company's steel furnaces at the same or other locations.

Table 6.—Manganese ore used in producing ferromanganese, silicomanganese, and manganese metal in the United States in 1976, by source of ore

Source	Gross weight (short tons)	Mn content, natural (percent)
Domestic[1]	53,632	44
Foreign:		
Africa	463,441	47
Australia	123,119	50
Brazil	394,445	48
Cuba[1]	44,351	48
India	80,502	47
Mexico	35,972	39
U.S.S.R.[1]	17,737	48
Unidentified	48,769	--
Total	1,261,968	47

[1]Most, if not all, from U.S. Government surplus stockpile disposals.

Silicomanganese.—Production of silicomanganese in the United States decreased to 129,000 short tons from the 143,000 tons of 1975. This is net production produced for shipment and does not include silicomanganese produced for use as an intermediate in the same plant for the production of medium- or low-carbon ferromanganese. Silicomanganese shipments from furnaces were 132,000 tons, compared with 126,000 tons in 1975 and 192,000 tons in 1974. Six companies used nine plants to produce silicomanganese for shipment in 1976: Airco Alloys Div., Airco Inc., Calvert City, Ky., and Theodore (Mobile), Ala; Interlake Inc. (Globe Metallurgical Div.), Beverly, Ohio; Ohio Ferro-Alloys Corp., Philo, Ohio; Roane Electric Furnace Co. (Englehard Minerals & Chemicals Corp.), Rockwood, Tenn.; Tenn-Tex Alloy Corp. of Houston, Houston, Tex.; and Union Carbide Corp., Alloy, W.Va., Marietta, Ohio, and Portland, Oreg. End-use consumption of silicomanganese—that is, consumption outside the ferroalloy plants—was 17.2% that of ferromanganese, compared with 18.2% in 1975 and 15.9% in 1974.

Spiegeleisen.—The New Jersey Zinc. Co. stopped its production of spiegeleisen at midyear. Production was from electric furnaces at Palmerton, Pa.

Pig Iron.—A total of 368,000 short tons of manganese-bearing ores containing 5% or more manganese (natural) was consumed in the production of pig iron (or its equivalent hot metal). Domestic sources supplied 237,000 tons, of which 191,000 tons was manganiferous iron ore containing 5% to 10% manganese, 33,000 tons was ferruginous manganese ore containing 10% to 35% manganese, and 13,000 tons was manganese ore containing 35% or more manganese that was apparently obtained from GSA through its program for disposal of stockpile excesses. Foreign sources supplied 131,000 tons, of which 1,000 tons was manganiferous iron ore and 130,000 tons was manganese ore containing 35% or more manganese.

Battery and Miscellaneous Industries.—The ore reported in table 3 includes that consumed in making synthetic manganese dioxide by both electrolytic and chemical means, but it does not include consumption of the synthetic dioxide. Although some synthetic dioxide is used for chemical purposes, most of it is used in the manufacture of dry-cell batteries, particularly for the manganese-alkaline type, premium or heavy-duty Leclanché (manganese dioxide-ammonium chloride-zinc) cells, and as a blend with natural ore in ordinary Leclanché cells.

The domestic ore and much of the foreign ore used for chemical and miscellaneous purposes did not meet national stockpile specification P-81-R for chemical-grade ore.

PRICES

Manganese Ore.—All manganese ore prices are negotiated. In addition to the manganese content, they are dependent on the chemical analysis otherwise, the physical character, quantity offered, delivery terms, fluctuating ocean freight rates, insurance, inclusion or exclusion of duties if applicable, needs of the buyer, and the general availability of ores that will fill these particular needs. Trade journal quotations reflect the paper's evaluation of the market. Contract prices for 1976 delivery of metallurgical manganese ore, having a minimum manganese content of 47% to 48%, ranged from $1.45 to $1.53 per long ton unit, c.i.f. U.S. ports. Because of large stocks in the hands of consumers and low demand, most contracts were not finalized before April. Normally they are signed in October or November of the preceding year.

Although spot purchases of ore were at one time a factor in the market, they were of little consequence in 1976 and immediately preceding years. Contracts for ore to be delivered in 1977 had not been negotiated by yearend 1976.

Manganese Alloys.—The published domestic producer price for standard high-carbon ferromanganese, having a minimum manganese content of 78%, was cut $15 early in January to $425 per long ton of alloy, and it remained at that figure for the remainder of the year. Quotes for imported alloy of the same grade dropped during the year from a range of $390 to $415, delivered in the Midwest, to $345 to $355 per long ton at yearend. Lower prices of the range, at least in the latter part of the year, were reported to be for large tonnages deliverable through 1977; the higher prices were for smaller spot tonnages. Lower grades of alloy reportedly brought even lower prices.

Manganese Metal.—In September, the price of standard and comparable grades of electrolytic manganese metal chips, packed in pallet boxes, increased by 4 cents to 58 cents per pound, f.o.b. producer plant, for shipments of 30,000 pounds or more. The bulk price continued to be 1 cent lower. These prices prevailed for the remainder of the year.

FOREIGN TRADE

Exports of ferromanganese totaled 6,789 short tons valued at $3,461,560, compared with 32,300 tons valued at $10,601,354 in 1975. Of the 1976 total, Canada took 3,346 tons; Sweden, 2,076 tons; West Germany, 828 tons; Mexico, 166 tons; Venezuela, 133 tons; the Dominican Republic, 121 tons; Brazil, 44 tons; Jamaica, 20 tons; Colombia, 15 tons; Bolivia and Guatemala, each 11 tons; Italy, 10 tons; Israel, 5 tons; Malaysia, 2 tons; and Chile, 1 ton. Exports classified as "manganese and manganese alloys, wrought or unwrought, and waste and scrap" totaled 4,654 tons valued at $3,433,918, compared with 3,256 tons valued at $3,318,322 in 1975. This classification includes electrolytic manganese metal and manganese-copper alloys, but it does not include ferromanganese. Exports of ore and concentrate containing more than 10% manganese amounted to 127,971 tons valued at $7,509,928, compared with 204,523 tons in 1975 valued at $13,886,100. Of the 1976 total, large quantities having relatively low average values were distributed as follows: Mexico, 34,000 tons; Norway, 22,000 tons; and Spain, 18,000 tons. For the most part, these tonnages appear to have been metallurgical ore obtained from GSA sales of Government excess stocks. Most of the remainder is believed to have been imported manganese dioxide ore that may or may not have been subjected to grinding, blending, or otherwise classifying in the United States.

The average grade of imported manganese ore was 49% manganese in 1976, the same as in 1975. Gabon supplied 41% in 1976; Brazil, 25%; Australia, 18%; and the Republic of South Africa, 10%. There were no imports of manganiferous ore (more than 10% but less than 35% manganese).

Table 7.—U.S. imports[1] of manganese ore (35% or more Mn), by country

Country	1975			1976		
	Gross weight (short tons)	Mn content (short tons)	Value (thousands)	Gross weight (short tons)	Mn content (short tons)	Value (thousands)
Australia	171,146	86,541	$8,443	234,636	117,367	$12,048
Brazil	633,076	307,367	30,012	333,479	161,108	18,033
Congo[2]	--	--	--	26,572	13,286	2,238
Gabon[3]	488,073	244,796	26,526	513,078	256,412	31,731
Mexico	52,327	23,171	1,724	39,831	18,485	1,994
Morocco	--	--	--	25,782	18,688	1,545
South Africa, Republic of	206,013	92,211	9,663	137,316	60,963	5,890
Zaire	23,410	11,444	735	6,118	2,936	148
Total	1,574,045	765,530	77,103	1,316,812	649,245	73,627

[1]Quantities for general imports and imports for consumption were identical.
[2]Actually from Gabon.
[3]In addition in 1976, Gabon imports reported as Congo were 26,572 tons (gross weight).

Ferromanganese imports for consumption increased 28% over the record high attained in 1974, or 35% over the 1975 tonnage. The Republic of South Africa, France, and Japan were the principal suppliers. Silicomanganese imports for consumption totaled 80,118 short tons containing 53,693 tons of manganese. Sources and gross weight tonnages follow: Norway, 31,825; Yugoslavia, 13,630; Brazil, 10,995; Spain, 6,646; Japan, 4,981; France, 3,472; Portugal, 3,362; the Republic of South Africa, 2,759; Mexico, 1,775; Canada, 578; Chile, 73; and Belgium, 22. Imports for consumption classified as unwrought manganese metal, except alloys, and metal waste and scrap totaled 7,082 short tons, compared with 4,378 tons in 1975. Of the 1976 total, 6,181 tons were from the Republic of South Africa, 483 tons from Japan, and 418 tons from Canada. It is most probable that the metal from Canada originated in the Republic of South Africa.

Imports for consumption classified as "manganese compounds, other" totaled 3,467 short tons, compared with 1,394 tons in 1975 and 3,086 tons in 1974. The sources, gross weights, and values per pound in 1976 follow: Japan, 2,796 tons (36 cents); Belgium, 458 tons (30 cents); the United Kingdom, 147 tons (4 cents); West Germany, 44 tons (75 cents); the Netherlands, 20 tons (31 cents) ;Ireland, 1 ton (49 cents); Brazil, 1 ton (32 cents); and Greece, 1/2 ton (37 cents). The imports from Japan, Belgium, the Netherlands, Ireland, Greece, and possibly Brazil appear to have consisted largely, if not entirely, of synthetic manganese dioxide. Manganese sulfate imports totaled 50 tons, of which 40 tons was from Belgium and 10 tons from Japan.

Tariffs.—Suspension of the duty on manganese ore from most nations, Rate 1, was extended another 3 years (through June 30, 1979) by Public Law 94-560. The suspended tariff remained at 0.12 cent per pound of contained manganese. The statutory rate continued to be 1 cent per pound of contained manganese, still applicable to ore of the U.S.S.R. and the People's Republic of China. The respective rates of duty for metal and the principal manganese ferroalloys remained unchanged. However, as of January 1, 1976, the United States accorded duty-free treatment under the Generalized System of Preferences (GSP) to imports of ferromanganese and silicomanganese from developing nations. A petition of The Ferroalloys Association to the Office of Special Representative for Trade Negotiations for relief from this action was rejected.

Table 8.—U.S. imports for consumption of ferromanganese,by country

Country	1975			1976		
	Gross weight (short tons)	Mn content (short tons)	Value (thousands)	Gross weight (short tons)	Mn content (short tons)	Value (thousands)
Belgium-Luxembourg	3,483	2,675	$1,059	33,136	25,338	$9,834
Brazil	6,228	4,787	2,136	7,578	5,802	1,855
Canada	952	702	167	10,566	8,294	3,902
Chile	--	--	--	95	74	31
France	138,999	107,058	45,127	119,762	92,556	38,314
Germany, West	827	689	730	20	17	16
India	5,977	4,557	1,301	12,115	9,140	2,965
Italy	--	--	--	439	351	230
Japan	73,851	56,111	27,584	114,111	88,680	40,786
Mexico	--	--	--	44	33	19
Norway	22,891	17,371	6,723	27,770	21,775	7,594
Portugal	661	510	202	10,957	8,340	2,485
South Africa, Republic of	121,456	94,885	34,304	174,183	135,599	46,636
Spain	9,541	7,925	5,234	19,413	15,942	8,188
Taiwan	11,243	8,507	3,502	5,677	4,288	1,403
United Kingdom	1	1	1	--	--	--
Yugoslavia	1,102	872	311	1,543	1,204	440
Total	397,212	306,650	128,381	537,409	417,433	164,698

WORLD REVIEW

An agreement in principle was reached by subsidiaries of Lockheed Aircraft Corp. (Lockheed Missiles & Space Co., Inc.), Standard Oil Co. of Indiana (Amoco Minerals Co.), and Royal Dutch-Shell (Billiton International Metals B.V.) for a joint venture to develop technology for mining and processing deep-sea manganese nodules. It was expected that Lockheed would be the operator for the venture.

Algeria.—Deposits of manganese ore at Guettara, estimated to have an average manganese content of 45% to 50%, were deemed to be of sufficient size by Société Nationale de Recherche et d'Exploitation Minière (SONAREM) to warrant further investigation.

Australia.—Groote Eylandt Mining Co. Pty. Ltd. completed its planned expansion of capacity at its Groote Eylandt, Northern Territory, open pit mine to 2 million metric tons of shipping products per year and was giving consideration to further expansion in the near future if market conditions permit. The affiliated Tasmanian Electro Metallurgical Co. Pty. Ltd. (TEMCO) completed the first stage of its expansion program at its Bell Bay, Tasmania, plant with the installation of a 600-ton-per-day Lurgi sintering machine to be used for sintering Groote Eylandt fines for feed to its two furnaces that currently produce ferromanganese and silicomanganese. A new 27-megavoltampere (MVA) furnace, which will increase production of these alloys, was to come onstream before yearend. Any sinter excess to the company's own requirements will be exported.

Bolivia.—The Government of Bolivia decreed that all manganese ore and iron ore deposits belong to the state, and that companies operating concessions do so in accord with guidelines to be established by Empresa Siderúrgica Boliviana S.A. (SIDERSA), the Government-owned iron and steel company. Nonoperating concessions were canceled. SIDERSA engaged Arthur G. McKee Co., Cleveland, Ohio, to make a feasibility study of an integrated steel industry based on the iron-manganese deposit at Mutún, located about 19 miles south of Puerto Suarez, Santa Cruz, not far from the Urucum manganese deposits of Brazil. After some drilling, it appears that the San Pedrito manganese occurrence at Mutún is a lens of limited extent, less than 10 feet thick, at the base of the primary iron ore formation (Banda Alta). There are reported to be other manganese beds or lenses in the Banda Alta, but it is not clear as to what their significance might be. The Banda Alta primary iron ore formation is some 650 to 1000 feet thick. All manganese ore production will be for export under control of SIDERSA, with expectations for marketing 30,000 metric tons in 1977 to Argentina, West Germany, or Brazil. Hand mining of small deposits of manganese ore in the Western Cordilleras has been responsible for Bolivia's production of recent years, and this production is expected to continue with marketing also through SIDERSA. The ore occurs as pyrolusite filling of faults and fissures in rhyolitic beds.

Botswana.—The manganese deposit of the formerly worked Kgwakgwe mine area, south of Kanye, lies in a shale horizon with an upper zone, some 6 feet thick, of metallurgical ore and a lower layer consisting of a massive accumulation of battery-grade manganese nodules having a manganese dioxide content greater than 70%. This latter material has been almost exhausted, but more than 200,000 metric tons of the metallurgical ore is estimated to remain. The Otse deposit, near the southeast coast and associated with conglomerates and chert breccias overlying shales and quartzites, was being reinvestigated. The ore analyzes approximately 40% to 47% manganese dioxide. The deposit at the Lobatse mine area is of variable grade occurring in shales at the base of a quartzite horizon. It was formerly worked on both sides of the Transvaal border, and remaining reserves are thought to be small although the reef has a strike length of approximately 2 miles. Mining has also been done in the past in the same general region some 2 miles south of Ramotswa. The ore occurs in a friable sandstone horizon associated with quartzite, and reserves are not known. Farther north in the Chadibe and Tswapong areas there is a manganiferous sandstone horizon with a thickness of 3 to 6 feet, and grades estimated to vary between 30% and 60% manganese dioxide. The bed has not been systematically explored but has a total strike length of about 28 miles.[2]

Brazil.—Shipments of Amapá manganese ore by Indústria e Comércio de Minerios,

[2]Baldock, J. W., J. V. Hepworth, and B. S. Marengwa. Gold, Base Metals, and Diamonds in Botswana. Econ. Geol., v. 71, January-February 1976, p. 150.

Table 9.—Manganese ore: World production by country

(Short tons)

Country[1]	Percent Mn[e]	1974	1975	1976[p]
North America: Mexico[2]	35+	444,379	472,295	465,803
South America:				
Argentina	25-30	28,728	34,588	[e]35,000
Bolivia[2]	28+	[3]565	[3]1,362	13,520
Brazil	38-50	[4]1,971,597	[4]2,376,527	[e]2,400,000
Chile	36-42	31,631	22,064	26,058
Peru	27-38	1,801	1,801	2,254
Europe:				
Bulgaria	30-	37,500	38,600	44,100
Greece	50	8,763	9,132	7,419
Hungary	30-	148,150	201,023	192,986
Italy	27	15,441	--	--
Portugal	37-40	78	--	--
U.S.S.R.[5]	35	[r]8,989,000	9,324,000	9,370,000
Yugoslavia	30+	14,641	18,657	20,944
Africa:				
Botswana	30+	9	--	--
Egypt	35+	5,453	3,983	4,691
Gabon	50-53	2,274,957	2,443,556	2,371,721
Ghana	30-50	275,856	450,560	343,780
Morocco	53	192,662	144,344	129,305
South Africa, Republic of	30+	5,230,886	6,359,262	6,010,079
Zaire	35-55	317,172	340,090	[e]172,600
Asia:				
Burma	NA	[e]310	--	--
China, People's Republic of [e]	30+	1,100,000	1,100,000	1,100,000
India[6]	10-54	[r]1,656,000	1,688,000	1,862,000
Indonesia	47+	[r]19,882	15,082	9,678
Iran[7]	33+	33,100	39,700	44,100
Japan	27-45	183,621	174,089	156,244
Korea, Republic of (South)	40	2,323	3,483	1,524
Pakistan	35-	8	85	[e]85
Philippines	45	945	--	11,658
Thailand	46-50	[r]31,930	27,463	48,290
Turkey	35+	3,571	20,544	[8]22,958
Oceania:				
Australia	37-53	1,677,704	1,713,992	2,374,560
New Hebrides	42-44	52,151	51,279	[e]51,000
Total	NA	[r]24,750,814	27,075,561	27,292,357

[e]Estimate. [p]Preliminary. [r]Revised. NA Not available.

[1]In addition to the countries listed, Colombia, Cuba, and the Territory of South-West Africa may have produced manganese ore and/or manganiferous ore, but available information is inadequate to make reliable estimates of output levels. Low grade ore not included in this table has been reported as follows in short tons: Czechoslovakia (about 17% Mn) 1974—1,072, 1975—1,101, 1976—1,212; Malaysia (grade unspecified but apparently a manganiferous ferruginous ore) 1974—93,985, 1975—146,947, 1976—103,741; Romania (about 22% Mn) 1974—155,000, 1975—155,000, 1976—155,000; the Republic of South Africa (15-30% Mn, in addition to material listed in table) 1974—98,769, 1975—123,131, 1976—56,178; Turkey (under 35% Mn, in addition to material listed in table) 1974—1,550, 1975—16,846, 1976—NA.

[2]Estimated on the basis of reported contained manganese.

[3]Exports.

[4]Figures are the sum of: 1) sales of direct shipping manganese ore, and 2) production of beneficiated ore, both as reported in the 1975 and 1976 editions of Anuario Mineral Brasileiro.

[5]Source: The National Economy of the U.S.S.R., Central Statistical Administration, Moscow. Grade represents the annual averages obtained from reported metal contents of the gross weights shown in the table.

[6]Of total 1973 output, 64% graded below 35% Mn and 36% exceeded that grade. Comparable production breakdowns for 1974-1976 are not available, but 71% of total 1974 exports of 1,140,453 short tons were below 35% Mn.

[7]Reported as if data are for calendar years, but may actually represent output for Iranian calendar years beginning March 21 of the year stated.

[8]May include some ore under 35% Mn (see footnote 1).

S.A. (ICOMI) were 1,047,000 metric tons, including 149,300 tons of pellets, in 1976 compared with 1,254,055 metric tons, including 100,509 tons of pellets, in 1975. The 1976 shipments were loaded out to export and domestic markets in 59 vessel cargoes, with those for export going to 15 countries besides the United States: Argentina, Belgium, Canada, Chile, Czechoslovakia, England, France, Germany, Greece, Italy, Japan, the Netherlands, Norway, Romania, and Spain.[3] Domestic sales in 1976 were approximately 120,000 tons.

In April, a new company, Urucum Mineração S.A., was formed to mine the Urucum manganese ore deposit near the Bolivian border in the Corumba area of the State of Mato Grosso. The Government-owned Cia. Vale do Rio Doce S.A. (CVRD), the State-owned Cia. Matogrossense de Mineração (METAMAT), and the privately owned Cia. Vale do Paraupeba (Alcindo Vieira group), each held one-third interest. The ore was previously mined by SOBRA-

[3]Skillings' Mining Review. V. 66, No. 11, Mar. 12, 1977, p. 21.

MIL, a company in which United States Steel Corp. had a substantial interest, but there has been no mining since 1972. Before the deposits can be fully developed, problems of transportation and of high alkali and high phosphorus content must be overcome. Output was expected to be for both domestic consumption and export with mining to start before yearend.

Cia. Paulista de Ferro-Ligas, a ferroalloy producer headquartered in São Paulo, was readying a new plant at Corumba for production of ferromanganese from Urucum ore by mid-1977. The plant will use two 4-MVA furnaces in a two-step process expected to solve the high-phosphorus, high-alkali problem, while producing 24,000 metric tons per year of high-carbon ferromanganese and silicomanganese. Approximately half of the production will be for export. Company plans also propose two similar furnaces to begin producing ferromanganese and silicomanganese at Macapa, Amapá, by the end of 1977. The annual capacity of this plant would be 24,000 tons, also.

In June, Construtora Alcindo Vieira—CONVAP S.A. (CONVAP), a Brazilian contracting company, together with METAMAT formed a new company, Cia. Matogrossense de Ferro-Ligas (FERMAT), with plans to install five 20-MVA furnaces by 1982 in a new plant at Três Lagoas, near the Jupiá hydroelectric plant northwest of São Paulo at the eastern boundary of the state of Mato Grosso. Plans called for the first two furnaces to begin production of high-carbon ferromanganese and silicomanganese from Urucum ore in 1981, half for domestic consumption and half for export. Research was conducted in 1976 on the best metallurgy to use on the iron-rich, high-alkali Urucum ore.

France.—Société Française d'Électrométallurgie (SOFREM), a subsidiary of Pechiney Ugine Kuhlmann, brought onstream new capacity for production of low- or medium-carbon ferromanganese, in the amount of 12,000 metric tons per year, at its St. Beron plant in southeastern France (Savoie). This brought SOFREM's total productive capacity for manganese ferroalloys to 60,000 tons per year.

Gabon.—All of the metallurgical manganese ore produced at Moanda by Cie. Minière de l'Ogooué (COMILOG) was for export, with the United States taking 42%, France 22%, and Japan 12%. West Germany and the United Kingdom were other major customers. United States Steel Corp. was COMILOG's principal shareholder with 44% interest; Gabonese interests, either principally or entirely as the Government, held 10% or 11%; and the remainder was held by the French Government's mining exploration company (BRGM), the French mining group Mokta, and interests of the Banque de Paris et des Pays-Bas (PARIBAS). Negotiations were conducted with the Congolese transportation authorities to improve the Congo-Ocean Railway's portion of the present route that the ore must take for export; that is, via the Congolese port of Point Noire. In the meantime, work began on construction of the Transgabon Railroad, expected to reach Moanda by the end of 1980. This will provide an all-Gabon route, permitting exports of 4 to 4.5 million tons per year by this route alone by the late 1980's via Gabon ports near Libreville. Société Gabonaise de Ferro-Alliages (SOGAFERRO) was formed with the objective of constructing a manganese ferroalloy plant near Moanda, dependent on completion of the railroad and expansion of the present hydroelectric installation at Poubara by construction of a large new dam, Grand Poubara. Feasibility studies were underway for both the dam and the ferromanganese projects, with thinking for the latter in terms of a plant to produce 85,000 tons of ferromanganese and 50,000 tons of silicomanganese per year. COMILOG held a 15% interest in SOGAFERRO; Japanese interests 25% (Okura Trading, Nippon Kokan K.K., and Nippon Denko K.K.); Union Carbide Corp, 10%; and the Gabon Government, 10%; the remainder was divided among French (Aciers de Paris), Norwegian (Elkem), Belgian (SADACEM), and Italian (Tassara) firms. In addition to being exported, Moanda's battery ore is consumed locally in the dry-cell plant of SOGAPIL, which produces 6 million dry cells annually for the Gabon market and for export. Another company, SOGADEMA, has been formed by COMILOG, or affiliates, together with United States and Belgian interests, to use manganese derivatives in the manufacture of glass and pharmaceutical products in the Moanda area.[4] Battery- and chemical-grade ore produced in 1976 totaled 65,000 metric tons. This ore is obtained by selective mining; it is not a separate ore body. The deposit is essentially horizontal, and manganese carbonates underlie the oxide ore.

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[4]Wall Street Journal. Gabon Pursues Its Ambitious Development Program. V. 188, No. 61, Sept. 29, 1976, p. 23.

Ghana.—Both battery-grade and metallurgical-grade oxide ore continued to be produced. Nationalization of manganese mining operations was completed in 1975, and mining continued by Ghana National Manganese Corp. Manganese exports in 1976 were approximately 350,000 tons, of which roughly 150,000 tons was carbonate ore and 200,000 tons was oxide, mostly metallurgical, ore. Battery ore exports all went to the United Kingdom. Carbonate ore went to synthetic dioxide plants in Japan and Ireland, and to electric furnace ferromanganese plants in Norway, Portugal, and elsewhere, where it was used to make up about 15% of the charge to the furnaces. It appears that the oxide ores will be exhausted within the next 5 years. Reserves of carbonate ore, a grayish mixed carbonate, were estimated from drilling to amount to 20 million tons averaging 30% manganese.

Greece.—Exports of pyrolusite in 1975 were 1,900 metric tons, of which 1,600 tons went to West Germany and 300 tons went to other countries.

Hungary.—Reserves of oxide ore occur in the Urkút area. Carbonate ore reserves are located at Urkút, Eger, and Demjen, but production of this ore was very limited for lack of technology to use it economically.[5] Ore produced in 1975 averaged about 27.8% manganese content.

India.—During the period 1968 through 1974, 88.5% of the manganese dioxide consumed in India was for the manufacture of dry-cell batteries, 8.5% went to the chemical industry, 1.6% to paints, 0.9% to glass, and the remaining 0.5% to the electrode, foundry, and ceramic industries. A total of 16,600 metric tons was consumed in 1974, of which 2,240 tons was electrolytic manganese dioxide. Preliminary production figures for manganese dioxide ore in 1975 totaled 11,700 tons, of which 4,400 tons came from Maharashtra and the remainder from Orissa. Imports of 4,800 tons in the first half of 1975 came from Gabon. For batteries, the imported ore is usually blended with the domestic ores, and supply of the latter of suitable character was a problem.

The only producer of electrolytic (synthetic) manganese dioxide in 1976 was Electrolytic Manganese Co., Division of Union Carbide India Ltd, Thana, Maharashtra, with licensed capacity of 2,500 tons and production in 1974, 1973, and 1972 of 2,229, 1,479, and 1,600 tons, respectively. Four other firms have received letters of intent or industrial licenses for its manufacture at annual capacities ranging from 1,000 to 4,000 tons, but it was doubted that any of these proposals could contribute to supply within the next 3 or 4 years.[6]

The average pit head price for manganese ore produced in 1976 was $8.07 per metric ton, compared with $7.61 in 1975. In February 1976, 182 mines reported production. Central Provinces Manganese Ore Co. Ltd. continued to hold 49% interest in Manganese Ore India Ltd. (MOIL) with the remaining ownership held by the Government of India and the State governments of Maharashtra and Madhya Pradesh. Developments suggested that MOIL would become a fully-owned public sector company before the end of 1977. Based at Nagpur, Maharashtra, it operated five mines in Maharashtra and three in Madyha Pradesh. One of the latter, the Balaghat mine 120 miles northeast of Nagpur, is the largest manganese mine in India with three steeply dipping ore zones, six levels, and a 600-foot shaft, annually producing approximately 75,000 tons of ore. Only about 55% of the manganese contained in the deposit is recovered in the concentrate shipped, but it has been estimated that additional milling facilities might improve this to 75%.

Manganiferous ore containing 30% to 35% manganese was used in the blast furnaces of the Durgapur, Bhilai and Bokaro steel plants at a rate of 50 kilograms per ton of hot metal produced; the rate at the Rourkela plant was nearly 150 kilograms per ton.

Indonesia.—All manganese ore produced in 1976 came from West Java or Central Java, and almost all was of battery grade, which was used domestically or exported to Japan.

Ireland.—The electrolytic manganese dioxide plant of Mitsui Denman (Ireland) Ltd. started production in February and by mid-July was operating at 70% of its capacity of 12,000 tons per year. The Irish Government has a 5% equity interest in the plant with the balance held by Mitsui Mining & Smelting Co., Ltd, Tokyo, and Mitsui & Co., Ltd., Tokyo. All production will be for export.[7]

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[5]Mining Journal (London). 1976 Mining Annual Review. June 1976, p. 498.

[6]Mineral Economics Division, Indian Bureau of Mines (Nagpur). Manganese Dioxide—A Market Survey. Market Survey: M.S. 3, August 1976, 38 pp.

[7]LeCerf, B. Mitsui's Manganese Refinery In Ireland Hits 70% Capacity. Am. Metal Market, v. 83, No. 139, July 16, 1976, p. 23.

Italy.—Mining of manganese ore ended in 1975 with exhaustion of Italsider's Gambatesa mine in Genoa Province.

Japan.—Production of ferromanganese in 1976 was 632,000 metric tons; silicomanganese, 373,000 tons; electrolytic manganese metal, 6,752 tons; and synthetic manganese dioxide, 32,540 tons. The manganese ore produced in 1976 had an average manganese content of 27.3%, except for 17 tons of dioxide ore having a manganese dioxide content of 65%.

Mexico.—In September, Cía. Minera Autlán S.A. de C.V., brought the first of its manganese ferroalloy furnaces onstream at its new plant at Tamos in the municipal district of Pánuco, State of Veracruz, 12 miles from Tampico.

Morocco.—The manganese ore produced in 1975 was chemical-grade ore or concentrate with an average manganese dioxide content of 83%.

New Hebrides.—Manganese ore (concentrate) produced and exported in 1975 had a minimum guaranteed manganese content of 40%, and the exports were estimated to run about 43%.

Norway.—Production of ferromanganese was 354,000 metric tons in 1976 and 331,000 tons in 1975; silicomanganese production was 173,000 and 200,000 tons, respectively.

Peru.—The manganese ore produced in 1975 had a manganese content of 37.5%. That produced in 1974 averaged 36.2% manganese (previously reported provisionally as 31% manganese).

Philippines.—An average manganese content of 44% to 45% was reported for the manganese ore produced in 1976.

Portugal.—Manganiferous iron ore produced in 1976 totaled 17,870 metric tons averaging 40.7% iron and 8.5% manganese.

South Africa, Republic of.—Production of electrolytic manganese metal in 1976 was 32,750 metric tons, almost equally divided between Delta Manganese (Pty.) Ltd. (DELTA) at 16,500 tons and Electrolytic Metal Corp. (Pty.) Ltd. (EMCOR) at 16,250 tons. Manganese-bearing effluents from the processing of uranium ores were originally used as the raw material for South Africa's electrolytic manganese metal industry. However, because of cobalticyanide impurities and other problems peculiar to use of this manganese source, it was decided in 1968 to use ore from northern Cape Province in spite of its high iron content of 10% to 12%. Normally low-iron ores, 1% to 2% iron, are used in the electrolytic production of the metal. Consequently, some changes were necessary in order to adapt to this ore. The resulting Delta flow sheet has four main components: 1) Reduction of the manganese in the ore from valence 4 to valence 2 to make it readily soluble in sulfuric acid; 2) reverse leaching in spent sulfuric acid electrolyte to minimize solution of iron; 3) purification of the leach solution; and 4) electrolysis of the purified solution. Electrolytic manganese metal production's overall efficiency is 68%, compared with 98% for copper. The South Africans claim to be the lowest cost electrolytic manganese metal producers, but recent and projected electric power costs could change this position. Power costs constitute approximately 25% of total production costs. Because use of the argon-oxygen process for the production of stainless steel allows the use of high-carbon ferromanganese instead of the electrolytic metal normally used in production of stainless steel, and use of this process is growing, the outlook for growth in demand for electrolytic manganese metal has shifted to an expanding use in aluminum resulting from growing popularity of the all-aluminum beverage can, containing 1% to 1.2% manganese, and to the high-strength low-alloy steels used in high-rise buildings and in large-diameter pipe lines for Arctic areas.[8] South Africa's production capacity for electrolytic manganese metal at the end of 1976 was 35,000 metric tons, divided equally between the two companies.

Northern Cape Province ores are of four general types: 1) In the Western and Eastern Belts of the Postmasburg field, brecciated unconsolidated ore and replacement bodies associated with dolomite karst topography; 2) in the Western Belt of the Postmasburg field, replacement of Gamagara shale closely associated with dolomite; 3) at Rooinekke, replacement and surface enrichment of banded iron formation and flagstone in the uppermost succession of the Dolomite Series; and 4) in the Kalahari (Kuruman) field, syngenetic deposits with three horizons of manganese oxides in banded iron formation near its base, the iron formation overlying Ongeluk lava and containing a band of calcareous dolomite in its upper portion. Low-grade metamorphism has transformed the manganese occurrences of the Postmasburg and Kalahari

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[8]S. A. Mining & Engineering Journal. S.A.'s Electrolytic Manganese Industry: A World Leader. V. 88, No. 4126, March 1977, pp. 47-50.

fields into hard, compact ores consisting mainly of braunite and bixbyite with minor quantities of hausmannite, jacobsite, todorokite, manganite, etc.[9]

Marble Lime & Associated Industries, Ltd. was reported to have sold its Gopani manganese mine for approximately $138,000 to Rand Corp.[10] —apparently Rand London Manganese Mines (Pty.) Ltd., a subsidiary of Rand London Corp. The Gopani mine, located near Zeerust, Transvaal, is an underground producer of battery grade (plus 65% manganese dioxide) and uranium-grade (plus 40% manganese dioxide) ore. It has a long-term contract to supply uranium-grade ore to the Rossing Uranium operation in the Territory of South-West Africa (Namibia). Anglo-American Corp. of South Africa Ltd. began development of an underground manganese ore mine at the Middleplaats deposit northwest of Kuruman. Substantial reserves averaging 38% manganese were indicated, together with a large tonnage of lower grade material that might be recoverable. The ore lies approximately 1,300 feet below the surface. It was planned to produce annually, by mechanical methods, 900,000 metric tons of metallurgical-grade ore and 200,000 tons of lower grade ferruginous ore.

Highveld Steel and Vanadium Corp., Ltd., a subsidiary of Anglo-American Corp. of South Africa Ltd., in July acquired a 65% equity interest in Transalloys (Pty.) Ltd., a manganese ferroalloy producer with a plant adjacent to Highveld's steel plant. Equipment at the Transalloys plant included two smelting furnaces for silicomanganese and two melting furnaces for medium-carbon ferromanganese. An additional large smelting furnace for production of silicomanganese was under construction with completion scheduled for mid-1977. Transalloys is an important supplier to Highveld as well as an exporter. Increasing power costs were adversely affecting its competitive position in world markets, although its sales were reported as satisfactory for the last half of 1976.

Production of the various grades of ore in 1976 and 1975 follow, in metric tons (1975 in parentheses): Metallurgical ore— 30% to 40% manganese, 3,358,000 (3,872,000); 40% to 45%, 209,000 (233,000); 45% to 48%, 1,517,000 (1,379,000); over 48%, 270,000 (199,000); chemical ore—35% to 65% manganese dioxide, 95,000 (79,000) tons; 65% to 75%, 3,000 (7,000) tons. Production of ferruginous manganese ore containing 15% to 30% manganese and 20% to 35% iron was 51,000 tons in 1976 and 112,000 tons in 1975. Local sales of the various grades of ore in 1976 and 1975 follow (1975 in parentheses): Metallurgical ore—30% to 40% manganese, 1,135,000 (1,013,000); 40% to 45%, 60,000 (34,000); 45% to 48%, 460,000 (517,000); over 48%, 20,000 (zero); chemical ore— 35% to 65% manganese dioxide, 82,000 (78,000); 65% to 75%, 3,000 (9,000). Local sales of ferruginous ore were zero in both years. Similarly, exports for the 2 years follow: Metallurgical ore—30% to 40% manganese, 2,015,000 (2,076,000); 40% to 45%, 51,000 (70,000); 45% to 48%, 1,258,000 (1,174,000); over 48%, 123,000 (82,000); chemical ore—35% to 65% manganese dioxide, zero both years; 65% to 75%, estimated 215 (1,000); ferruginous ore—estimated 295,000 (238,000).

Spain.—Approximately 60% of the labor force at Hidro Nitro Española's ferromanganese plant at Monzon went on strike December 17 over pay rates.[11] In 1976, the company produced 32,000 metric tons of ferromanganese and 36,000 tons of silicomanganese. Production in 1975 was 29,000 and 34,000 tons, respectively.[12]

Thailand.—Production of battery-grade manganese ore (75% manganese dioxide) in 1976 was 3,000 metric tons, while exports were 1,000 tons. Chemical ore production (75% manganese dioxide and up) was 130 tons with no exports. The metallurgical ore produced was reported to range in manganese content from 46% to 50%; exports were 42,000 tons, compared with 23,000 tons in 1975.

U.S.S.R.—The contract for the previously proposed large new high-carbon ferromanganese plant was awarded to Japan's Tanabe Kakoki over the bids of United States, Norwegian, and West German firms. Six fully sealed 75,000-kilovoltampere furnaces will have shell diameters in excess of 15 meters; each will use three 2-meter electrodes.[13] The 1976 delivered price of $34.25 per metric ton for ferruginous manganese ore containing 28% to 29% manga-

[9]Hammerbeck, E. C. I., and J. J. Taljaardt. Manganese. Ch. in Mineral Resources of the Republic of South Africa, Fifth Edition, Handbook 7, ed. by C. B. Coatzee. Geological Survey, Department of Mines, Republic of South Africa, 1976, pp. 167-172.

[10]Metal Bulletin (London). No. 6153, Dec. 21, 1976, p. 26.

[11]Metal Bulletin (London). No. 6159, Jan. 18, 1977, p. 25.

[12]Metal Bulletin (London). No. 6185, Apr. 19, 1977, p. 25.

[13]Saito, F. Japan's Tanabe Gets Soviet Pact for 6 Furnaces for Ferromanganese Output. Am. Metal Market, v. 83, No. 122, June 22, 1976, p. 2.

nese was agreed to by Soyuzpromexport and Japan's Nippon Kokan for 1977 delivery of 100,000 metric tons with buyer's option for an additional 50,000 tons.[14]

The Ordzhonikidze Complex (Kombinat) in the Nikopol' basin of the Ukraine, producing approximately 4.3 million tons of concentrated shipping products per year, has seven open pits, three beneficiating plants, and one sintering plant. Roughly 55% to 60% of the concentrates were used in the U.S.S.R., and the remainder was exported to other East European countries. The ore occurs as a gently south-dipping sedimentary bed up to 10 feet thick—carbonates on the south grading into oxides on the north—lying under 160 to 260 feet of overburden consisting of rich black topsoil above layers of clay, loess, sands, shells, and in some places limestone. Large bucket-wheel excavators in conjunction with extensive systems of portable and fixed conveyors remove the overburden, stacking the respective materials in separate piles for subsequent blending in the reclamation operations. Average thickness of the ore mined in the north pit in 1973 was 6 feet; ratio of overburden to ore was 27 cubic yards per ton. The ore has an average manganese content of 25% and is all beneficiated to two products for shipment: First class, with a manganese content of 45% to 50%, for the production of manganese ferroalloys; and second class, containing 35% to 38% manganese, for use in iron blast furnaces. Heavy media and flotation methods are employed, and 80% of the manganese in the ore is recovered. The tailings, which contain 20% manganese, are saved, and plans call for their later recovery in an electrolytic manganese metal plant to be built before 1980. The land is reclaimed, not to its original contour but improved for present and future agricultural, recreational, and aesthetic needs. This involves the management of some 260 million cubic yards of displaced material per year. With the aid of agronomists and much research since 1962, better agricultural yields have been obtained for a variety of crops than were had before mining.

United Kingdom.—In 1975, 85,000 metric tons of ferromanganese and 100 tons of spiegeleisen were produced, compared with 83,000 and 8,000 tons, respectively, in 1974.

Yugoslavia.—Production of ferromanganese in 1974, 1973, and 1972 was 23,000, 19,000, and 19,000 metric tons, respectively; similarly, silicomanganese production was 17,000, 12,000, and 15,000 tons. The only producer was Tvornica Elektroda I Ferolegura, in Croatia.

Zaire.—The Kisenge deposits in southwestern Shaba are almost vertical lenticular deposits of primary, very hard manganese carbonate ore, having a manganese content of 30%, oxidized to the enriched, also very hard, oxide ores analyzing up to 57% manganese. Although the tonnages of carbonate ore mined have been small, consideration was being given to their greater utilization. There were four open pits—Kisenge, Kamata Principale, Kamata Rive Gauche, and Kapolo—aligned along an east-west axis over a distance of 10 kilometers. Extraction of the ore has required the removal of twice as much overburden, by volume, as ore. Bucyrus-Erie shovels and Euclid trucks, working one shift per day, annually send 500,000 tons of oxide ore to the washing plant where the ore is crushed, washed free of clay and talc, sized into two fractions by screening or elutriation, and the fines further classified into two fractions.[15]

Although no manganese ore was shipped in 1976 owing to continued closure of the Benguela Railroad since August 1975, Zaire's only manganese producer, Société Minière de Kisenge (SMK), continued to mine and stockpile the ore at Kisenge, operating by means of a monthly subsidy from the Government of Zaire. The stockpile was estimated to contain approximately 550,000 tons of ore by yearend, roughly representing 2 years of production.

TECHNOLOGY

The Bureau of Mines extended its research on manganese-copper damping alloys from the cast alloys to powder metallurgy consolidations. Damping capacity was enhanced, and potential savings in material and labor were suggested. Strength and ductility were considerably lower, however, than for comparable cast alloys.[16]

The Panel on Manganese Recovery Technology of the Committee on Technical

[14]Metals Week. V. 48, No. 4, Jan. 24, 1977, p. 6.

[15]Elima (Lubumbashi, Zaire). L'exploitation du manganèse au Zaire. Feb. 5, 1975, pp. 2-4. (From Bulletin No. 9, Institut de Gestion du Portefeuille, Lubumbashi, Zaire, January 1975.)

[16]Holman, J. L., and L. A. Neumeier. Proc. 5th Internat. Powder Met. Conf., Chicago, Ill., June 27-July 3, 1976, pp. 1-25.

Aspects of Critical and Strategic Materials, National Materials Advisory Board, National Research Council/National Academy of Sciences, assessed the present technology for recovering and processing manganese from domestically available resources. It concluded that the two land-based domestic resources best suited for development on a significant scale were the Cuyuna deposits of Minnesota and the Aroostook deposits of Maine; also, that the deep-sea nodule deposits, particularly some in the Pacific Ocean, were a very important potential source of manganese and that the lower grade Atlantic Ocean deposits of the Blake Plateau might be considered to be domestically available. The most feasible manganese recovery processes were considered to be the ammonium carbamate process and the sulfur dioxide roast (high-temperature differential sulfatization) process. In both cases, however, "Questions concerning performance, cost, and environmental impact remain to be resolved" even though extensive development work has been done in the past at scales of 200 and of 2 tons of ore per day, respectively.[17]

Factors to be considered in the selection of a suitable mine site for recovery of ocean floor manganese nodules follow: Nodule population—the percentage of the sea floor covered by visible nodules; nodule concentration—the weight per unit area, a function of population, size, shape, and specific gravity; nodule assay—many published analyses are too high because the barren core was not included in the material analyzed; bathymetry—water depth; topography of the sea floor; geotechnic data—bearing strength of the floor; environmental data; and ecological requirements.[18] Although the nodules typically lie only on the surface, some nodule layers are buried a few centimeters in the sediments. These sediments in great part are quite weak, but they can change quickly to firm. A difficult decision to be made for the nodule-collecting machinery and operation is the trade-off between velocity and collecting width; 3 kilometers per hour and a width greater than 10 meters are a likely optimum.[19]

In a discussion of the past, present, and future role of manganese in the production of steel, it was concluded that the declining use of manganese as a desulfurizer and deoxidant, as a result of improvements in steelmaking techniques, was being countered by a growing realization of the importance of manganese as an alloying element in itself.[20]

The Carpenter Steel Div., Carpenter Technology Corp., made commercially available its patented 18-18 Plus stainless steel, containing approximately 18% manganese and 18% chromium. Yield strength is twice that of Type 304 stainless, and corrosion resistance is similar to that of Type 316 in most applications. Prices approximated those of Type 316 products[21]

Continuous production of "Massive Manganese" is accomplished by Chemetals Div., Diamond Shamrock Corp., by its patented fused-salt electrolytic process. The product is in lump form, and the regular grade typically analyzes 93% manganese, 6% iron, 0.14% carbon, 0.15% silicon, 0.16% phosphorus, and 0.02% sulfur; the high-purity grade analyzes 98% manganese, 1.8% iron, 0.12% carbon, 0.06% silicon, 0.01% phosphorus, and 0.02% sulfur. The reduction cell used resembles that used to produce aluminum by the Hall process. Feed typically consists of manganous oxide in the form of a reduced ore, fluorspar (CaF_2), and calcium oxide (lime), with CaF_2 making up at least 50% by weight of the fused electrolyte. The operating temperature is approximately 1,300° C, and the melt is removed by tapping in much the same manner as an open hearth melting furnace is tapped.[22]

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[17] National Materials Advisory Board, National Research Council-National Academy of Sciences. Manganese Recovery Technology. NMAB-323, 1976, 81 pp.

[18] Siapno, W. D. Exploration Technology and Ocean Mining Parameters. Min. Cong. J., v. 62, No. 5, May 1976, pp. 16-22.

[19] Pasho, D. W. A Qualitative Consideration of Some Mining Machine Seafloor Interactions. Proc. Joint MMIJ-AIME Meeting, Denver, Colo., September 1-3, 1976, v. 1, pp. 283-305.

[20] Desforges, C. D., W. E. Duckworth, and T. F. J. N. Ryan. Manganese in Ferrous Metallurgy. The Manganese Centre (Neuilly sur Seine, Paris), 1976, 87 pp.

[21] American Metal Market. New Car Tech Alloy Available. V. 83, No. 149, July 30, 1976, p. 3.

[22] Welsh, J. Y., and J. P. Faunce. The Production of Manganese Metal Pres. at 105th Annual Meeting, AIME, Las Vegas, Nev., February 22-26, 1976, 7 pp.

Mercury

By Harold J. Drake[1]

U.S. mine production of mercury in 1976 totaled 23,133 flasks[2] valued at an estimated $2.8 million. Production was reported from seven mines, five in California and two in Nevada. Production tripled for the second consecutive year, primarily because output at the new McDermitt mine in Nevada nearly reached design capacity.

Secondary production continued to decline and totaled 3,363 flasks including 520 flasks sold by the General Services Administration (GSA).

Consumption rose 28% to 64,870 flasks. The advance was led by sharply increased demand for use in electrical apparatus, which was accompanied by increases in demand for use in catalysts, chlorine and caustic soda production, industrial and control instruments, and mildew-proofing paints. Declines were reported for dental preparations and pharmaceuticals.

Producer, consumer, and dealer stocks continued to rise and by yearend totaled 31,734 flasks, a level 24% above that at yearend 1975. Producer stocks nearly doubled, while consumer and dealer stocks rose about 7%.

Prices declined through the first 8 months of 1976, but rose thereafter and finished the year at $135 per flask in New York and $103 per flask in London. The monthly average flask price in New York was $121.25, compared with $158.12 in 1975. Comparable figures for London were $91.97 and $130.11, respectively.

Exports and reexports totaled 513 flasks, compared with 494 flasks in 1975. Imports for consumption increased slightly to 44,415 flasks, a level that accounted for 68% of the U.S. market for mercury. Algeria, Italy, Yugoslavia, Spain, and the People's Republic of China were the principal sources of imported mercury.

World production in 1976 totaled 243,987 flasks, compared with 252,429 flasks in 1975. Producers in Italy, Spain, and the U.S.S.R. reportedly discontinued sales of mercury in 1976; concomitantly, Italian and Mexican producers sharply curtailed or completely shut down mercury mining operations. Canadian mining operations, suspended in 1975, did not reopen in 1976. An international association of mercury producers reportedly met intermittently during 1976.

Legislation and Government Programs.—The Government, through the Office of Minerals Exploration, U.S. Geological Survey, is authorized to loan up to 75% of approved costs for mercury exploration, but no new funds were available for contracts in 1976. GSA offered for sale 500 flasks of mercury monthly during 1976 but sold only 520 flasks.

In December 1975, an administrative law judge for the Environmental Protection Agency (EPA) ruled that phenylmercurials could be used in latex paint products and certain other products but not in oil-based paints. The ruling ended nearly 4 years of administrative proceedings, including hearings, which began when EPA attempted to cancel registrations of all biocides containing mercury but met legal challenges from biocide producers. EPA placed a ban on all mercury-containing biocides. Pesticide producers again challenged the ban and EPA postponed the ban first to June 30, 1976, and then to November 30. A final settlement was reached in August which provided for the use of mercury in water-based paints and other coatings and the temporary use of mercury biocides to treat

[1]Physical scientist, Division of Nonferrous Metals.
[2]Flask as used throughout this chapter refers to the 76-pound flask.

summer golf turf diseases and certain farm seeds until August 31, 1978, or whenever the equivalent of 2 years production of the latter biocides is attained. Use of mercury-based biocides on winter golf turf diseases under strictly controlled conditions was also allowed by EPA.

Congress took no action on authorizing the release of surplus mercury in the strategic stockpile. At yearend, the stockpile contained 191,407 flasks. GSA established a new goal of 54,004 flasks, leaving 137,403 flasks available for disposal.

Table 1.—Salient mercury statistics

	1972	1973	1974	1975	1976
United States:					
Producing mines	37	24	12	r13	7
Production flasks	7,349	2,227	2,189	7,366	23,133
Value thousands	$1,604	$637	$617	r$1,165	$2,806
Exports flasks	400	342	466	339	501
Reexports do	563	--	--	155	12
Imports:					
For consumption do	28,834	46,026	52,180	43,865	44,415
General do	29,179	46,076	52,102	44,472	43,964
Stocks, Dec. 31 do	15,708	17,946	19,877	25,549	31,734
Consumption do	52,907	54,283	59,479	50,838	64,870
Price: New York, average per flask	$218.28	$286.23	$281.69	$158.12	$121.25
World:					
Production flasks	278,968	r268,265	r257,477	r252,429	243,987
Price: London, average per flask	$203.01	$273.54	$267.94	$130.11	$91.97

rRevised.

DOMESTIC PRODUCTION

Production of primary mercury totaled 23,133 flasks in 1976 compared with 7,366 flasks in 1975. Only six mercury mines reported production: the Oat Hill, the Aetna, the New Almaden, the Knoxville, and the Manhattan-One Shot in California, and the McDermitt in Nevada. Byproduct mercury was produced at a gold mine in Nevada. The sharply increased output of primary mercury was accounted for by the new McDermitt mine in Nevada. Startup problems at the mine's ore-processing facilities were resolved by the end of 1975, and full-scale production was achieved throughout most of 1976.

The average grade of all ore processed in 1976, including ore processed at concentrators, increased to 9.5 pounds of mercury per ton. The increase in the grade of ore was accounted for by the McDermitt mine.

Production of secondary mercury, exclusive of GSA sales, amounted to 2,843 flasks, 62% below that of 1975. Most of the decline in secondary production was due to the low price of mercury, which made it cheaper to buy mercury by the flask than to process scrap into usable mercury. Major sources of secondary mercury were industrial and control instruments, batteries, sludges, and dental amalgams.

Table 2.—Mercury produced in the United States, by State

Year and State	Producing mines[1]	Flasks	Value[2] (thousands)
1975			
California	r19	878	r$139
Nevada and New York	4	6,488	r1,026
Total	r13	7,366	r1,165
1976			
California and Nevada	7	23,133	2,806

rRevised.
[1]Mercury mines only.
[2]Value calculated at average New York price.

Table 3.—Mercury ore treated and mercury produced in the United States[1]

Year	Ore treated (short tons)	Mercury produced: Flasks	Mercury produced: Pounds per ton of ore
1972	82,580	[2]7,004	6.5
1973	26,257	[2]2,101	6.1
1974	28,858	[2]1,680	4.4
1975	76,772	6,905	6.8
1976	185,103	23,042	9.5

[1]Excludes mercury produced from old surface ores, dumps, and placers, and as a byproduct.
[2]Includes mercury contained in concentrate for export.

Table 4.—Production of secondary mercury in the United States

(Flasks)

Year	Industrial production	GSA releases	Total
1972	12,139	512	12,651
1973	7,746	2,583	10,329
1974	5,940	2,353	8,293
1975	7,538	500	8,038
1976	2,843	520	3,363

CONSUMPTION AND USES

Consumption, reversing a decline in 1975, resumed the upward trend of recent years and increased 28% from the 1975 level to 64,870 flasks. Of the major uses, electrical apparatus rose 62% to 27,498 flasks, and mildew-proofing paint rose 13% to 7,845 flasks. Use in the production of chlorine and caustic soda rose 5% to 16,054 flasks, and use in industrial and control instruments rose 10% to 5,067 flasks. Other unspecified uses, in the aggregate, rose 66% to 2,909 flasks. Other major changes were dental preparations, down 15%; and catalysts, up 51%. Use in pharmaceuticals fell sharply, from 445 flasks in 1975 to 60 flasks in 1976.

Of the 64,870 flasks consumed in 1976, 78% consisted of primary mercury, 19% was redistilled mercury, and 3% was secondary mercury. Primary mercury was used throughout the whole range of applications, while redistilled mercury was used primarily in electrical apparatus, industrial and control instruments, and dental preparations. Secondary mercury was used mainly in industrial and control instruments, electrical apparatus, dental preparations, and catalysts.

Table 5.—Mercury consumed in the United States, by use

(Flasks)

Use	1972	1973	1974	1975	1976
Agriculture[1]	1,836	1,830	980	600	607
Amalgamation	--	--	--	7	11
Catalysts	800	673	1,298	838	1,264
Dental preparations	2,983	2,679	3,024	2,340	1,990
Electrical apparatus	15,553	18,000	19,678	16,971	27,498
Electrolytic preparation of chlorine and caustic soda	11,519	13,070	16,897	15,222	16,054
General laboratory use	594	658	476	335	595
Industrial and control instruments	6,541	7,155	6,202	4,598	5,067
Paint:					
Antifouling	32	32	6	--	--
Mildew-proofing	8,190	7,571	6,807	6,928	7,845
Paper and pulp manufacture	1	--	--	--	--
Pharmaceuticals	578	606	597	445	60
Other[2]	4,258	1,913	2,452	1,750	2,909
Total known uses	52,885	54,187	58,417	50,034	63,900
Total unknown uses	22	96	1,062	804	970
Grand total	52,907	54,283	59,479	50,838	64,870

[1]Includes fungicides and bactericides for industrial purposes.
[2]Includes mercury used for installation and expansion of chlorine and caustic soda plants.

Table 6.—Mercury consumed in the United States in 1976

(Flasks)

	Primary	Redistilled	Secondary	Total
Agriculture[1]	607	--	--	607
Catalysts	987	180	97	1,264
Dental preparations	643	1,231	116	1,990
Electrical apparatus	19,546	7,527	425	27,498
Electrolytic preparation of chlorine and caustic soda	16,049	--	5	16,054
General laboratory use	420	165	10	595
Industrial and control instruments	2,172	2,265	630	5,067
Paint: Mildew-proofing	7,845	--	--	7,845
Pharmaceuticals	60	W	--	60
Other[2]	2,231	672	17	2,920
Total known uses	50,560	12,040	1,300	63,900
Total unkown uses	36	399	535	970
Grand total	50,596	12,439	1,835	64,870

W Withheld to avoid disclosing individual company confidential data; included in "Other."
[1]Includes fungicides and bactericides for industrial purposes.
[2]Includes amalgamation.

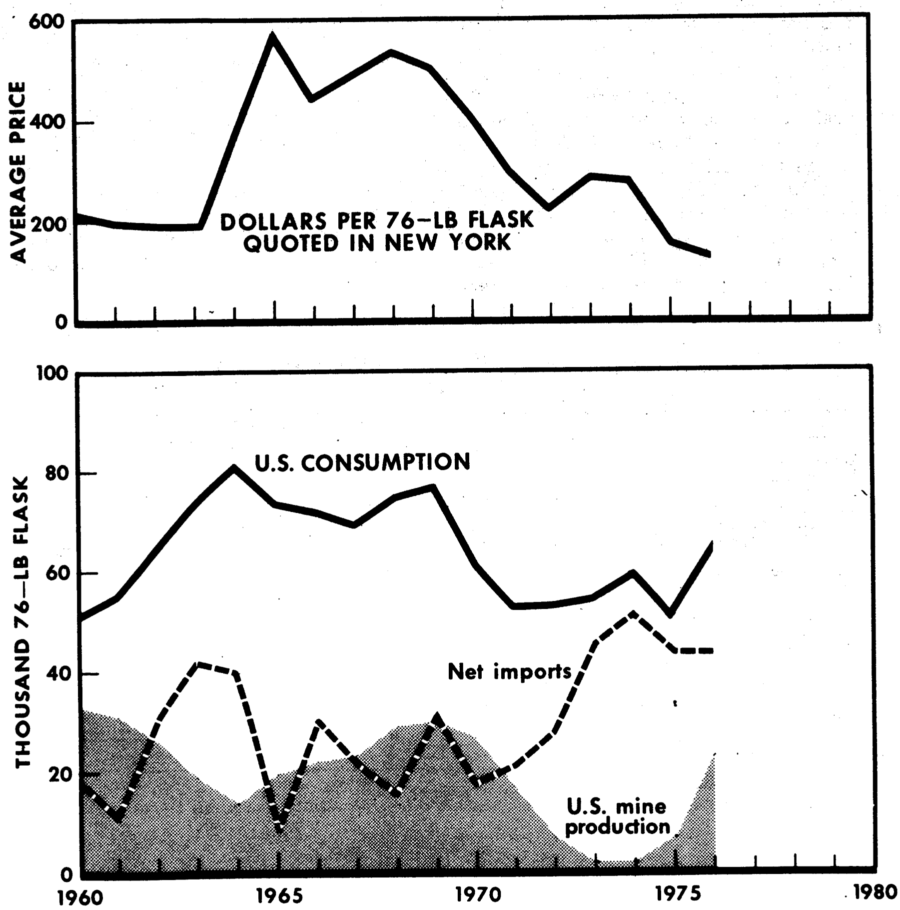

Figure 1.—Trends in production, consumption, and price of mercury.

Table 7.—Stocks of mercury, December 31

(Flasks)

Year	Producer	Consumer and dealer	Total
1972	4,171	11,537	15,708
1973	3,927	14,019	17,946
1974	4,100	15,777	19,877
1975	4,858	20,691	25,549
1976	9,494	22,240	31,734

STOCKS

Stocks of mercury at yearend 1976 totaled 31,734 flasks, compared with 25,549 flasks at yearend 1975. Producer stocks were up sharply from 4,858 flasks at yearend 1975 to 9,494 flasks at yearend 1976. The increase in producer stocks was accompanied by an increase of 1,549 flasks to 22,240 flasks held by consumers and dealers.

PRICES

Prices of primary mercury rose in the early part of 1976 but fell back during the middle months before resuming the rise in September. On January 8, 1976, the New York price of mercury was $116 to $122 per flask, compared with $132 to $135 per flask on December 28, 1976. The average monthly New York price was $121.25 per flask in 1976, compared with $158.12 per flask in 1975. The London price showed similar fluctuations. At the beginning of 1976 the London price was $80 to $85 per flask, compared with $104 to $110 per flask at yearend 1976. The average annual London price was $91.97 per flask in 1976, compared with $130.10 per flask in 1975. The national and international price increases late in 1976 were attributed to the reported discontinuance of mercury sales by Italy, Spain, and the U.S.S.R. and to reduction in output by producers in Mexico.

Table 8.—Average monthly prices of mercury at New York and London

(Per flask)

	1975		1976	
	New York[1]	London[2]	New York[1]	London[2]
January	$221.36	$183.75	$117.00	$81.38
February	225.11	194.69	124.72	94.51
March	195.43	170.00	128.22	99.06
April	162.73	141.75	127.91	99.63
May	159.57	137.06	113.50	82.00
June	152.38	127.50	109.05	82.50
July	138.73	114.69	108.18	83.25
August	138.95	114.67	108.18	83.25
September	135.48	111.69	122.43	87.75
October	129.59	103.07	132.25	100.23
November	120.82	84.08	131.42	101.67
December	117.23	78.28	132.13	108.38
Average	158.12	130.10	121.25	91.97

[1]Metals Week, New York.
[2]Metal Bulletin, London; reported in terms of U.S. dollars.

FOREIGN TRADE

Exports of mercury totaled 501 flasks valued at $306,000, compared with 339 flasks valued at $152,000 in 1975. Reexports totaled 12 flasks valued at $6,000 in 1976.

Imports for consumption increased 1% in quantity but declined 43% in value to 44,415 flasks valued at $4.3 million. The average unit value for the year was $97.38 per flask, compared with $173.24 per flask in 1975. The share of the U.S. market for mercury supplied by foreign countries amounted to 68%.

Italy continued to raise exports to the United States, and recorded a 79% increase in 1976 to 13,172 flasks valued at $1.2 million to become the largest foreign supplier of mercury. Imports from Algeria, the next largest supplier, rose 10% to 10,248 flasks valued at $1.1 million, while imports from Yugoslavia, the third largest source, rose 55% to 6,739 flasks valued at $658,000. Imports from Spain rose 5% to 4,824 flasks valued at $461,000. Imports from Canada, which in past years accounted for the largest share of imports, fell drastically to 2,853 flasks valued at $249,000 as a result of the cessation of mercury-mining operations in Canada. The People's Republic of China in 1976 became a significant exporter of mercury to the United States when its shipments reached 4,353 flasks valued at $360,000. Shipments from Mexico, another major source of imported mercury in past years, continued to decline and reached 1,719 flasks valued at $137,000 in 1976.

Imports from the principal supplying nations in the Western Hemisphere (Canada, Mexico, Peru, and the Philippines) in the aggregate, continued to decline, and totaled 4,872 flasks in 1976 compared with 16,129 flasks in 1975. Conversely, imports from the other principal suppliers (Algeria, Italy, Spain, and Yugoslavia) in the aggregate, rose during this time from 21,832 flasks in 1974 to 25,547 flasks in 1975 and 34,983 flasks in 1976.

The U.S. rate of duty on mercury imports during 1976 was 12.5 cents per pound ($9.50 per flask) with the duty on waste and scrap suspended until June 30, 1978. This rate applied to imports from market economy countries. The statutory rate of 25 cents per pound ($19 per flask) applied to centrally controlled economy countries.

Table 9.—U.S. exports and reexports of mercury

Year	Exports		Reexports	
	Flasks	Value (thousands)	Flasks	Value (thousands)
1974	466	$270	--	--
1975	339	152	155	$68
1976	501	306	12	6

WORLD REVIEW

World production of primary mercury declined 3% to 243,987 flasks in 1976. Although demand increased during 1976, large inventories throughout the world acted to reduce production and to moderate the upward movement of prices late in the year. An international organization of mercury producers reportedly met intermittently during 1976 mainly to review the mercury situation and try to bolster prices.

Canada.—Canadian mining operations, suspended because of low prices in 1975, did not reopen in 1976. Exports of inventory mercury continued in 1976, but by yearend these stocks were believed to be exhausted.

China, People's Republic of.—Production of mercury was estimated to total 26,000 flasks in 1976. In addition to sharply increased exports of mercury to the United States, significant quantities were reportedly exported to European countries.

Italy.—Mine production of mercury totaled 22,278 flasks, compared with 31,677 flasks in 1975. Italy's nonferrous metal agency, Ente Gestione Azienda Minerali Metallurgiche, reportedly closed its mercury mining operations and halted sales of the metal during 1976 because of low prices.

Table 10.—U.S. imports for consumption[1] of mercury, by country

Country	1974		1975		1976	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
Algeria	10,449	$2,843	9,296	$1,561	10,248	$1,110
Canada	16,972	4,592	12,891	1,840	2,853	249
China, People's Republic of	--	--	200	87	4,353	360
Finland	15	5	35	6	--	--
France	--	--	400	81	--	--
Germany, West	500	142	400	49	--	--
Hong Kong	--	--	--	--	200	18
Italy	845	212	7,340	1,595	13,172	1,244
Japan	45	13	--	--	--	--
Mexico	10,597	2,830	2,218	442	1,719	137
Netherlands	--	--	601	68	--	--
Peru	1,276	333	1,025	207	300	64
Philippines	100	26	--	--	--	--
Spain	6,293	1,624	4,575	963	4,824	461
Sweden	--	--	5	8	7	24
Switzerland	4	7	--	--	--	--
Turkey	353	96	58	14	--	--
United Kingdom	486	67	--	--	--	--
U.S.S.R	--	--	490	101	--	--
Yugoslavia	4,245	1,158	4,336	627	6,739	658
Total	52,180	13,948	43,865	7,599	44,415	4,325

[1]General imports: In 1974, 52,102 flasks ($13,858,283), Italy 705 flasks ($178,675) and Yugoslavia 4,307 flasks ($1,174,480); in 1975, 44,472 flasks ($7,223,497), Italy 7,525 flasks ($1,151,729), U.S.S.R. 600 flasks ($122,533), Yugoslavia 4,498 flasks ($645,967), and China (People's Republic of) 350 flasks ($64,885); in 1976, 43,964 flasks ($4,290,514), Italy 13,222 flasks ($1,251,930), and China (People's Republic of) 4,253 flasks ($353,559).

Table 11.—Mercury: World production, by country

(Flasks)

Country	1974	1975	1976[p]
Algeria	14,000	28,000	31,000
Australia	2	6	[e]6
Canada	14,000	12,000	--
Chile	921	97	13
China, People's Republic of[e]	26,000	26,000	26,000
Colombia	79	(1)	--
Czechoslovakia	5,541	[e]6,000	[e]6,000
Finland	183	309	383
Germany, West	[r]3,365	3,191	[e]3,200
Ireland	775	423	--
Italy	25,991	31,677	22,278
Japan	1,409	--	--
Mexico	25,933	14,214	15,026
Peru	[r]3,252	1,530	--
Philippines	812	244	--
Spain	[r]54,354	44,010	[e]44,000
Tunisia	(1)	(1)	--
Turkey	[r]8,833	5,421	[e]4,445
U.S.S.R.[e]	54,000	55,000	56,000
United States	2,189	7,366	23,133
Yugoslavia	15,838	16,941	12,503
Total	[r]257,477	252,429	243,987

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Revised to none.

Spain.—Production of mercury totaled 44,000 flasks, compared with 44,010 flasks in 1975. Spanish producers reportedly discontinued sales of mercury during 1976 because of low prices.

U.S.S.R.—Production of mercury was estimated to total 56,000 flasks. Because of low prices, Soviet suppliers reportedly withdrew from the international market in 1976.

Table 12.—Mercury: Exports from Italy, Spain, and Yugoslavia, by country

(Flasks)

Destinations	Italy			Spain			Yugoslavia		
	1974	1975	1976	1974	1975	1976	1974	1975	1976
Australia	--	--	NA	232	609	29	--	--	--
Austria	40	1,441	NA	--	29	174	100	--	--
Belgium-Luxembourg	2	[r]5,511	NA	87	1,073	--	--	--	--
Canada	280	--	NA	783	174	174	--	--	--
Colombia	--	3	NA	435	--	--	--	--	--
Egypt	--	474	NA	145	--	435	--	--	--
Finland	--	--	NA	--	--	174	--	--	--
France	[r]3,015	[r]3,634	NA	1,566	609	928	--	--	--
Germany, East	[r]4,303	[r]12,129	NA	--	--	--	--	--	--
Germany, West	[r]1,991	[r]5,930	13,663	6,295	1,682	580	--	--	--
Greece	--	4	NA	[r]1	--	--	--	--	--
Hungary	200	--	NA	--	174	174	200	--	--
India	--	[r]3,508	3,699	9,254	2,379	3,091	--	--	--
Iraq	--	--	NA	609	--	145	--	--	--
Japan	--	--	NA	696	435	899	--	--	--
Netherlands	400	[r]3,064	5,732	667	319	725	--	--	--
Poland	--	600	699	2,002	377	522	--	--	--
Portugal	114	50	NA	203	87	203	--	--	--
Romania	--	--	2,637	--	[r]2,030	4,032	--	--	--
South Africa, Republic of	520	45	NA	667	435	812	--	--	--
Sweden	--	302	NA	1,595	--	1,392	--	--	--
Switzerland	90	--	NA	667	87	29	50	--	--
Taiwan	100	--	NA	986	--	--	--	--	--
United Kingdom	[r]4,800	[r]5,801	3,742	[r]5,367	3,713	2,350	--	--	--
United States	[r]1,673	[r]6,642	NA	6,266	4,264	4,554	8,152	8,402	8,402
Other countries and undistributed	[r]650	[r]329	10,735	[r]667	[r]350	1,843	[r]1,009	--	--
Total	[r]18,178	[r]49,467	40,907	39,190	18,826	23,265	9,511	8,402	8,402

[r]Revised. NA Not available.

TECHNOLOGY

Scientists at the Federal Bureau of Mines Reno Metallurgy Research Center conducted an investigation of improved processes for recovering mercury from cinnabar ores.[3] The research was conducted on eight different mercury ores ranging in grade from 0.7 pound to 18 pounds of mercury per ton of ore and demonstrated that cinnabar ores were amenable to hydrometallurgical recovery by an electrooxidation procedure that recovered 88% to 96% of the mercury at a considerable savings in energy consumption.

A study of energy use patterns in the production of mercury and other metals was conducted for the Bureau of Mines.[4] The report detailed energy consumption in each operation in the production of mercury metal and concluded that total consumption of energy per ton of metallic mercury amounted to 395 million Btu.

A new mercury monitor to determine the occupational exposure of workers to mercury was developed at the National Bureau of Standards, U.S. Department of Commerce.[5] The monitor is extremely sensitive, portable, easy to use, inexpensive, and reusable. Use of mercury cells to produce chlorine may decline further as the result of the development of new membranes for use in diaphragm cells that also produce chlorine and caustic soda.[6] The new membrane, made from perfluorsulfonic acid resin, lasts much longer than the asbestos membranes currently in use and produces a more concentrated caustic soda containing less salt and chlorine containing no hydrogen. A patent was issued for treating roaster gases with sulfuric acid and potassium thiocyanate and treating the condensate solutions with sodium sulfide to precipitate mercury metal.[7]

[3]Shedd, E. S., B. J. Scheiner, and R. E. Lindstrom. Recovery of Mercury From Cinnabar Ores by Electrooxidation, Extraction Plant Amenability Tests. BuMines RI 8083, 1975, 13 pp.

[4]Battelle Columbus Laboratories. Energy Use Patterns in Metallurgical and Nonmetallic Mineral Processing. (Phase 6 - Energy Data and Flowsheets, Low-Priority Commodities). BuMines Open File Rept. 117(1)-76, 1976, pp. 126-130; available for consultation at the Bureau of Mines libraries in Tuscaloosa, Ala., College Park, Md., Twin Cities, Minn., Rolla, Mo., Boulder City, Nev., Reno, Nev., Albany, Oreg., and Salt Lake City, Utah; at the Central Library, U.S. Department of the Interior, Washington, D.C.; and from National Technical Information Service, Springfield, Va., PB 261 150/AS.

[5]American Paint & Coatings Journal. New Mercury Monitor Is Highly Sensitive. V. 60, No. 34, Feb. 2, 1976, p. 44.

[6]Chemical Week. New Membranes Cut Chlor-Alkali Costs. V. 118, No. 12, Mar. 24, 1976, pp. 33-36.

[7]Herrera, A. de la Cuadra, M.F. Tallante and A. R. Sanchez. (assigned to Patronato de Investigacion Cientificuy Tecnicu 'Juan de la Cierva Del Consejo Superior de Investigaciones Cientificas). Process for Purifying Metallurgical Gases Containing Sulphurous Anhydride by Extracting Mercury. U.S. Pat. 3,974,254, Aug. 10, 1976.

Mica

By Stanley K. Haines[1]

Production of sheet mica was limited to a small quantity of handpicked muscovite from North Carolina. Domestic production of scrap and flake mica decreased 6% in quantity while sales of ground mica increased 4%.

Consumption of block and film mica continued to decline reaching 534,229 pounds, a drop of 14%. Mica splittings consumption rebounded to 5,025,152 pounds. Exports of all forms of mica increased 40% in quantity and 2% in value. Imports of all forms of mica dropped 45%, led by a 61% decline in imports of waste and scrap mica.

Legislation and Government Programs.—The Defense Materials Inventory stockpile goals for sheet mica were revised in October. The goals for all forms except muscovite film were increased. The new goals are given in table 2. Shipments of excess mica by the General Services Administration (GSA) amounted to 3,319,348 pounds.

[1]Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient mica statistics

	1972	1973	1974	1975	1976
United States:					
Sold or used by producers:					
Sheet mica thousand pounds	14	30	20	5	5
Value thousands	$7	$15	$10	$3	$3
Scrap and flake mica thousand short tons	148	153	137	135	127
Value thousands	$4,353	$6,082	$5,475	$5,219	$5,686
Ground mica thousand short tons	130	137	117	r115	120
Value thousands	$8,844	$9,464	$10,171	r$9,381	$10,226
Consumption, block and film thousand pounds	1,207	1,265	974	623	534
Value thousands	$2,026	$2,106	$2,015	$1,608	$1,413
Consumption, splittings thousand pounds	4,324	5,178	6,186	4,746	5,025
Value thousands	$1,771	$1,715	$2,801	$2,634	$3,226
Exports thousand short tons	7	8	9	6	8
Imports for consumption do	5	6	7	8	5
World production thousand pounds	510,135	r525,709	r515,916	r499,464	471,082

rRevised.

Table 2.—Defense Materials Inventory for sheet mica as of December 31, 1976

(Pounds)

Category	Stockpile goal	Total inventory	Total excess	Balance of disposal authorization	Sold in 1976
Muscovite block, Stained or better	6,188,000	5,108,133	--	--	--
Muscovite film, 1st and 2d qualities	90,000	1,329,960	1,239,960	62,187	19,814
Muscovite splittings	12,631,000	22,542,341	9,911,341	3,482,466	1,186,078
Phlogopite block	206,064	127,773	--	--	--
Phlogopite splittings	932,000	3,047,953	2,115,953	2,097,953	357,975

DOMESTIC PRODUCTION

Sheet Mica.—A small quantity of sheet mica was produced and sold locally in North Carolina. Oxford Feldspar Co., West Paris, Maine, produced and stockpiled sheet mica in 1976. The sheet mica in both areas was generally of low quality and grade, and was not mined as the primary product of the producing company.

Scrap and Flake.—North Carolina retained its position as the leading producing State with 55% of the total U.S. production of 127,312 short tons. The value of the North Carolina mica was $3,793,295 or 67% of the national total. The remaining 45% of scrap and flake mica output came from Alabama, Arizona, Connecticut, Georgia, New Mexico, Pennsylvania, and South Carolina. Scrap and flake mica was produced from the beneficiation of pegmatite ores, clays, weathered pegmatites, and schists.

Leading producers of scrap and flake mica were Harris Mining Co., Spruce Pine, N.C.; Western Mica Co., Div. of United States Gypsum Co., Chicago, Ill.; Mineral Industrial Commodities of America, Inc., Santa Fe, N.Mex.; The Feldspar Corp., Spruce Pine, N.C.; and Kings Mountain Mica Co., Inc., Kings Mountain, N.C.

Ground Mica.—Sales of ground mica increased 4% in quantity and 9% in value over the revised 1975 totals. Dry-ground mica was 89% of the total, with wet-ground mica representing the remaining 11%. Both wet- and dry-ground mica production increased in quantity and value. Seventeen companies, operating a total of 19 plants, processed scrap and flake mica. Fourteen of these plants produced dry-ground mica, 3 produced wet-ground mica, and 2 produced wet- and dry-ground mica.

Table 3.—Mica sold or used by producers in the United States

Year and State	Sheet mica						Scrap and flake mica[1]	
	Uncut punch and circle mica		Uncut mica larger than punch and circle		Total sheet mica			
	Pounds	Value	Pounds	Value	Pounds	Value	Short tons	Value
1972	14,280	$7,140	--	--	14,280	$7,140	147,883	$4,353,313
1973	--	--	30,000	$15,000	30,000	15,000	153,327	6,081,893
1974	--	--	20,000	[e]10,000	[e]20,000	[e]10,000	136,966	5,474,636
1975	--	--	[e]5,000	[e]2,500	[e]5,000	[e]2,500	134,582	5,219,461
1976:								
North Carolina	--	--	[e]5,000	[e]2,500	[e]5,000	[e]2,500	70,213	3,793,295
Other States[2]	--	--	--	--	--	--	57,099	1,893,109
Total	--	--	[e]5,000	[e]2,500	[e]5,000	[e]2,500	127,312	5,686,404

[e]Estimate.
[1]Includes finely divided mica recovered from mica and sericite schist, and mica that is a byproduct of feldspar and kaolin beneficiation.
[2]Includes Alabama, Arizona, Connecticut, Georgia, New Mexico, Pennsylvania, and South Carolina.

Table 4.—Ground mica sold or used by producers in the United States, by method of grinding[1]

Year	Dry-ground		Wet-ground		Total[2]	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1972	104,625	$5,500	25,649	$3,343	130,274	$8,844
1973	120,762	6,469	15,739	2,995	136,501	9,464
1974	101,455	6,335	15,908	3,836	117,363	10,171
1975	[r]104,157	[r]6,551	11,244	2,829	[r]115,401	[r]9,381
1976	106,355	7,120	13,197	3,107	119,552	10,226

[r]Revised.
[1]Domestic and some imported scrap.
[2]Data may not add to totals shown because of independent rounding.

Leading producers of ground mica were Harris Mining Co., Spruce Pine, N.C.; United States Gypsum Co., Chicago, Ill.; Deneen Mica Co., Inc., Micaville, N.C.; and Mineral Industrial Commodities of America, Inc., Santa Fe, N.Mex.

CONSUMPTION AND USES

Sheet Mica.—Consumption of block and film mica dropped for the third consecutive year. Fabrication of block and film mica (muscovite and phlogopite) declined 14% to 534,229 pounds. Of the total consumption, 90% was muscovite block, 8% was phlogopite block (magnesium mica), and 2% was muscovite film.

Vacuum tubes required 66% of the total muscovite block fabricated. The remaining fabricated block was used in gage glass and diaphragms (3%) and capacitors and others uses (31%). Stained quality muscovite block mica was in greatest demand and accounted for 63% of consumption; lower than Stained, 35%; and Good Stained or better, 2%.

Muscovite film consumption increased from 7,243 pounds in 1975 to 10,266 pounds. The film was consumed primarily in the fabrication of capacitors.

Muscovite block and film were consumed by 10 companies in 7 States. North Carolina had three consuming plants, New Jersey had two, while Massachusetts, New York, Ohio, Pennsylvania, and Virginia had one plant each.

Phlogopite block consumption increased from 28,512 pounds in 1975 to 43,865 pounds. Phlogopite was consumed by eight companies in five States. Virginia and New Jersey were the primary fabricating States.

Consumption of mica splittings (muscovite and phlogopite) increased 6% from a total of 4,746,000 pounds in 1975 to 5,025,000 pounds. India and the Malagasy Republic supplied the bulk of the splittings consumed domestically. Splittings were fabricated into various built-up mica products by 10 companies with 11 plants in 8 States. Five plants located in Ohio, New York, and New Hampshire consumed 3.9 million pounds of splittings, or 79% of total consumption.

Built-Up Mica.—This mica-based product was made in various forms, primarily for

Table 5.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica, by quality and end-product use in the United States in 1976

(Pounds)

Variety, form, quality	Electronic uses				Nonelectronic uses			Grand total
	Capacitors	Tubes	Other	Total	Gage glass and diaphragms	Other	Total	
Muscovite:								
Block:								
Good Stained or better	990	5,892	1,838	8,720	2,520	1,113	3,633	12,353
Stained	203	230,020	38,384	268,607	1,884	30,557	32,441	301,048
Lower than Stained[1]	--	79,156	16,836	95,992	10,700	60,005	70,705	166,697
Total	1,193	315,068	57,058	373,319	15,104	91,675	106,779	480,098
Film:								
First quality	2,390	3,100	46	5,536	--	--	--	5,536
Second quality	3,219	--	186	3,405	--	--	--	3,405
Other quality	1,325	--	--	1,325	--	--	--	1,325
Total	6,934	3,100	232	10,266	--	--	--	10,266
Block and film:								
Good Stained or better[2]	3,380	8,992	1,884	14,256	2,520	1,113	3,633	17,889
Stained[3]	3,422	230,020	38,570	272,012	1,884	30,557	32,441	304,453
Lower than Stained	1,325	79,156	16,836	97,317	10,700	60,005	70,705	168,022
Total	8,127	318,168	57,290	383,585	15,104	91,675	106,779	490,364
Phlogopite: Block (all qualities)	--	200	358	558	--	43,307	43,307	43,865

[1]Includes punch mica.
[2]Includes first- and second-quality film.
[3]Includes other-quality film.

use as electrical insulating material. Molding plate, segment plate, heater plate, and other uses registered gains in production. Segment plate was the form in greatest demand, with 33% of the total, followed by molding plate with 28% and tape with 17%.

Reconstituted Mica (Mica Paper).—Five companies consumed 4,227,427 pounds of scrap mica to produce 2,715,158 pounds of mica paper in 1976. The manufacturing companies were General Electric Co., Schenectady, N.Y.; U.S. Samica Corp., Rutland, Vt.; Kirkwood Acim Paper Co., Hempstead, N.Y.; Essex Group, United Technologies Corp., New Market, N.H.; and Corona Films Inc., West Townsend, Mass.

Ground Mica.—Ground mica sales increased 4% above the revised 1975 level of 115,401 short tons. The principal end uses were joint cement (44%), paint (18%), roofing (4%), and rubber (4%).

Table 6.—Fabrication of muscovite ruby and nonruby block and film mica in the United States in 1976, by quality and grade

(Pounds)

Form, variety, and quality	No. 4 and larger	No. 5	No. 5 1/2	No. 6	Other[1]	Total
Block:						
Ruby:						
Good Stained or better	2,997	930	294	6,517	--	10,738
Stained	10,465	104,817	62,767	86,767	2,103	266,919
Lower than Stained	6,542	11,122	16,426	67,080	35,920	137,090
Total	20,004	116,869	79,487	160,364	38,023	414,747
Nonruby:						
Good Stained or better	1,292	123	--	200	--	1,615
Stained	25,729	3,943	2,052	2,405	--	34,129
Lower than Stained	4,572	10	--	3,150	21,875	29,607
Total	31,593	4,076	2,052	5,755	21,875	65,351
Film:						
Ruby:						
First quality	800	779	475	2,425	--	4,479
Second quality	103	930	1,100	275	--	2,408
Other quality	--	--	--	--	1,325	1,325
Total	903	1,709	1,575	2,700	1,325	8,212
Nonruby:						
First quality	--	17	620	420	--	1,057
Second quality	--	--	997	--	--	997
Other quality	--	--	--	--	--	--
Total	--	17	1,617	420	--	2,054

[1]Figures for block mica include all smaller than No. 6 grade and "punch" mica.

Table 7.—Consumption and stocks of mica splittings in the United States, by source

(Thousand pounds and thousand dollars)

	India		Malagasy		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:						
1972	4,245	1,658	79	113	4,324	1,771
1973	5,063	1,606	115	109	5,178	1,715
1974	6,026	2,673	160	128	6,186	2,801
1975	4,625	2,529	120	104	4,746	2,634
1976	4,903	3,084	122	142	5,025	3,226
Stocks Dec. 31:						
1972	1,723	NA	86	NA	1,809	NA
1973	1,246	NA	55	NA	1,301	NA
1974	3,170	NA	87	NA	3,257	NA
1975	3,465	NA	r44	NA	r3,510	NA
1976	3,166	NA	124	NA	3,290	NA

NA Not available.
[1]Data may not add to totals shown because of independent rounding.

Table 8.—Built-up mica[1] sold or used in the United States, by product

(Thousand pounds and thousand dollars)

Product	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Molding plate	1,272	2,790	1,381	3,033
Segment plate	1,557	3,605	1,620	4,063
Heater plate	155	428	179	256
Flexible (cold)	705	1,724	588	1,612
Tape	930	3,467	819	3,344
Other	253	1,075	329	1,165
Total[2]	4,872	13,089	4,915	13,474

[1]Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.
[2]Data may not add to totals shown because of independent rounding.

Table 9.—Ground mica sold or used by producers in the United States, by use

Use	1975 Short tons	1975 Value (thousands)	1976 Short tons	1976 Value (thousands)
Roofing	r10,406	r$464	5,011	$219
Rubber	4,336	936	4,680	1,010
Paint	22,298	2,657	21,224	2,362
Joint cement	r43,507	1,841	52,799	3,851
Other uses[1]	r34,854	r3,485	35,838	2,784
Total[2]	r115,401	r9,381	119,552	10,226

rRevised.
[1]Includes mica used for agricultural products, molded electric insulation, annealing, plastics, welding rods, well drilling, textile and decorative coating, wallpaper, and brick.
[2]Data may not add to totals shown because of independent rounding.

STOCKS

Yearend stocks of sheet mica were 3.7 million pounds. Of this total 88.6% was splittings, 11.2% was block, and 0.2% was film. This information was obtained by direct canvass of consumers of sheet mica.

PRICES

The average value of muscovite sheet in 1976, based on consumption data, follows: Block, $2.68 per pound; film, $4.33 per pound; and splittings, $0.64 per pound. The average value of phlogopite sheet mica, also based on consumption data, follows: Phlogopite block, $1.89 per pound, and phlogopite splittings, $0.87 per pound.

The average value of scrap and flake mica produced during 1976 was $44.67 per ton. Prices for wet- and dry-ground mica quoted in the Chemical Marketing Reporter essentially remained at 1975 levels.

Table 10.—Price of dry- or wet-ground mica in the United States in 1976[1]

	Cents per pound
Dry-ground:	
Joint cement, 100 mesh	4-5
Plastic, 100 mesh	4-5
Roofing, 20 to 80 mesh	2.5-3.5
Wet-ground:[2]	
Paint or lacquer, 325 mesh	11.75-13
Rubber	11.75-13
Wall paper	12-18

[1]In bags at works, carlots, unless otherwise noted.
[2]Freight allowed east of the Mississippi River.

Source: Chemical Marketing Reporter. V. 210, No. 26, Dec. 27, 1976.

FOREIGN TRADE

Exports of all forms of unmanufactured mica increased 32%, from 10,977,353 pounds in 1975 to 14,449,150 pounds. Canada led the increase with a jump of 96% to 6,660,106 pounds and an average value of slightly over 7 cents per pound indicating that the vast majority of the mica exported was ground. West Germany was the second leading country of destination for the exports, followed by Japan, France, and Guatemala. The overall average value of the exported mica was 24 cents per pound in 1976 as compared with 28.7 cents per pound in 1975. The average value indicates that most of the material exported was ground mica, but there was a large enough quantity of the more expensive sheet mica to raise the average value.

Imports of all classes of mica declined from 16,651,263 pounds in 1975 to 9,195,508 pounds in 1976. The largest changes were in the waste and scrap category with a drop of 61% to 4,212,574 pounds and splittings with a decrease of 55%. India was the leading source country with 60% of total imports with Brazil second with 20% of the total.

Table 11.—U.S. exports of mica and manufactures of mica in 1976, by country

Destination	Mica, including block, film, splittings, waste, scrap and ground mica		Manufactured	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Argentina	37,369	$49	13,516	$65
Australia	14,600	5	56,383	98
Bahrain	--	--	1,719	9
Belgium-Luxembourg	24,195	2	240	4
Brazil	37,295	13	116,668	451
Canada	6,660,106	499	261,978	1,020
Chile	2,400	7	474	3
Colombia	280,078	51	702	6
Costa Rica	7,486	1	22	1
Denmark	--	--	4,721	21
Dominican Republic	--	--	1,473	8
Ecuador	18,118	3	--	--
Egypt	402,000	59	--	--
El Salvador	273,229	14	21,286	28
Finland	46,195	13	--	--
France	616,276	87	3,194	62
Germany, West	667,914	129	--	--
Ghana	20,000	1	--	--
Greece	13,500	2	1,027	3
Guatemala	599,500	100	--	--
Hong Kong	9,167	15	--	--
Hungary	97,051	290	--	--
Iran	377,000	48	792	5
Israel	302,126	63	290	2
Italy	463,510	86	35,653	173
Jamaica	122,200	13	1,970	5
Japan	640,724	857	369	7
Korea, Republic of	24,116	29	--	--
Malaysia	56,400	9	--	--
Mexico	127,062	88	94,210	299
Netherlands	215,500	22	193	8
Norway	39,608	2	1,072	7
Panama	43,850	6	16,899	15
Peru	69,080	9	6,624	33
Poland	--	--	1,598,911	863
Philippines	29,000	5	--	--
Saudi Arabia	315,324	245	10,124	25
Singapore	455,028	103	1,133	3
South Africa, Republic of	--	--	23,480	66
Spain	58,748	12	87,744	218
Sweden	44,000	7	902	7
Taiwan	25,131	28	1,400	8
Tanzania	12,000	2	--	--
United Arab Emirates	448,800	73	232	3
United Kingdom	186,235	258	2,380	4
Venezuela	388,978	56	69,112	107
Yugoslavia	--	--	2,829	18
Other	178,251	116	41,429	121
Total	14,449,150	$3,477	2,481,151	$3,776

Table 12.—U.S. imports for consumption of mica, by kind and country

Year and country	Unmanufactured									
	Waste and scrap				Block mica		Other			
	Phlogopite		Other				Muscovite		Other, n.e.c.	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
1974	--	--	6,633,773	$193	582,832	$724	49,920	$21	160,638	$202
1975	--	--	10,672,125	356	247,681	507	1,084	13	655,727	176
1976:										
Afghanistan	--	--	--	--	--	--	538	3	--	--
Brazil	--	--	641,338	31	279,803	392	998	3	926,854	124
Canada	--	--	--	--	--	--	--	--	86,170	8
France	--	--	--	--	--	--	--	--	7,640	8
India	2,836	$3	3,568,400	171	57,171	236	1,169	9	267,885	70
Japan	--	--	--	--	146	2	--	--	--	--
Malagasy Republic	--	--	--	--	9,369	15	--	--	6,061	22
South Africa, Republic of	--	--	--	--	743	15	--	--	8,800	1
Tanzania	--	--	--	--	576	11	662	6	15	1
United Kingdom	--	--	--	--	20	4	73	11	--	--
Total	2,836	3	4,209,738	202	347,828	675	3,440	32	1,303,425	234

Year and country	Manufactured							
	Splittings		Not cut or stamped not over 0.0006 inch in thickness		Cut or stamped			
					Not over 0.0006 inch in thickness		Over 0.0006 inch in thickness	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
1974	4,970,618	$1,318	75,739	$37	122,934$	2,056	151,603	$265
1975	3,790,511	911	3,751	8	30,344	350	59,096	127
1976:								
Canada	174,645	9	--	--	5,700	8	2,451	15
Haiti	--	--	--	--	1,603	29	--	--
India	1,350,480	411	100	1	66,177	731	105,051	212
Japan	--	--	--	--	--	--	200	1
Laos	--	--	--	--	90	1	--	--
Malagasy Republic	185,848	141	--	--	--	--	11	(1)
Netherlands	--	--	--	--	--	--	4	1
Taiwan	--	--	--	--	449	16	--	--
United Kingdom	--	--	--	--	394	4	82	4
Total	1,710,973	561	100	1	74,413	789	107,799	233

Year and country	Mica plates and built-up mica		Ground or pulverized		Articles not especially provided for of mica	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
1974	906,110	$951	223,686$	16	102,832	$285
1975	973,638	1,255	201,996	22	15,310	262
1976:						
Belgium-Luxembourg	781,180	1,064	--	--	--	--
Canada	22,275	88	447,872	31	2,600	16
France	--	--	98,376	17	331	1
Germany, West	8,787	20	--	--	4,414	11
India	33,469	86	--	--	29,593	212
Italy	--	--	--	--	30	1
Japan	2,024	5	--	--	296	6
Mexico	145	2	--	--	--	--
Netherlands	--	--	--	--	143	21
Peru	60	8	--	--	--	--
Switzerland	--	--	606	(1)	--	--
United Kingdom	818	3	--	--	1,937	17
Total	848,758	1,276	546,854	48	39,344	285

[1]Less than 1/2 unit.

Table 13.—U.S. exports and imports of mica

(Thousand pounds and thousand dollars)

Year	Exports (all classes)		Imports for consumption					
			Uncut sheet and punch		Scrap		Manufactured	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1974	17,897	6,515	793	947	6,634	193	6,554	4,928
1975	12,110	7,104	904	696	10,672	356	5,075	2,935
1976	16,930	7,253	1,655	941	4,213	205	3,328	3,193

WORLD REVIEW

World production of all forms of mica declined 6% from 1975 to 1976. India was the world leader for production of sheet mica. Brazil and the Malagasy Republic were other major sheet mica producing countries. The United States remained the world leader in production of scrap and flake mica (for ground mica).

India.—The Government of India remained firm in their recommendation re-

Table 14.—Mica: World production, by country

(Thousand pounds)

Country[1]	1974	1975	1976[p]
Argentina:			
Sheet	939	948	[e]990
Waste, scrap, etc.	6,109	6,393	[e]6,600
Brazil[2]	[r]5,761	2,425	[e]2,400
Colombia[e]	90	90	90
Egypt	216	[e]220	[e]220
France[e]	8,800	8,800	8,800
India:			
Exports:			
Block[3]	[r]2,119	1,241	[e]1,800
Splittings[4]	[r]14,282	7,628	[e]8,800
Scrap[5]	61,970	26,389	[e]33,000
Domestic consumption, all classes[e]	23,810	[r]44,000	22,000
Total[e]	102,181	79,258	65,600
Korea, Republic of (sericite)	5,952	[e]6,600	11,715
Malagasy Republic (phlogopite):			
Block	333	218	15
Splittings	1,215	981	137
Scrap	340	--	26
Mexico	1,861	1,367	2,873
Mozambique (including scrap)	[r]1,878	1,984	[e]2,000
Nepal	9	9	10
Norway (including scrap)	9,167	16,435	[e]13,000
Peru	9	[e]10	[e]20
South Africa, Republic of:			
Sheet	[6]	[6]	--
Scrap	5,944	5,536	5,247
Sri Lanka (scrap)	397	5,432	302
Sudan	551	[e]550	1,213
Tanzania, sheet	20	13	15
U.S.S.R. (all grades)[e]	90,000	92,000	95,000
United States:			
Sheet	20	5	5
Scrap and flake	273,932	270,000	254,624
Yugoslavia	192	190	[e]180
Total	[r]515,916	499,464	471,082

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, the People's Republic of China, Romania, Southern Rhodesia, the Territory of South-West Africa and Sweden are known to produce mica, but available information is inadequate to make reliable estimates of output levels.

[2]Exports.

[3]Includes micanite and other built up mica.

[4]Includes condensed film, washer and disks.

[5]Includes sheet, strips, and powder.

[6]Less than 1/2 unit.

quiring 40% of all orders to be placed through the Government's Mica Trading Co. (MITCO), with the remaining 60% to be placed with traditional suppliers. MITCO concluded agreements with the U.S.S.R. for the supply of sheet mica in 1976. The U.S.S.R. was to receive about 35% of India's total mica exports on a value basis. East Germany also contracted for a large supply of sheet mica from India.

Malagasy Republic.—Mica (phlogopite) mining operations were shut down in January 1976 owing to lack of demand for phlogopite block and splittings. The 1,023 tons of mica exported was from stockpiles. Mining is expected to resume in mid-1977.

TECHNOLOGY

The U.S. Bureau of Mines research station in Tuscaloosa, Ala., successfully conducted preliminary tests to air classify mica from a mica mill tailings dump. The mica in these samples did not respond adequately to conventional beneficiation techniques. A sample containing 7% mica was screened and then air classified to recover the mica. This process resulted in a 72% mica concentrate.

Molybdenum

John T. Kummer[1]

World output of molybdenum increased about 8% over that of 1975, but was exceeded by demand. The result was some tightness in the molybdenum market, especially during the second half of 1976, and a drawdown of producer stocks. In the United States, mine production increased approximately 7% while total industry stocks were reduced almost 20%. Although reported domestic consumption of molybdenum products was down slightly, apparent demand increased 8.6% to almost 60 million pounds. Reduced availability of some molybdenum materials was reported during the latter part of 1976. The price of molybdenum concentrate and other primary products was increased three times during 1976, on each occasion by 8% to 10%. These increases were attributed to higher operating costs, large capital expenditures, and the increased demand for molybdenum materials during the year.

Legislation and Government Programs.—During 1976, the General Services Administration (GSA) sold 130,151 pounds of excess molybdenum contained in molybdenum disulfide, and as a result, no uncommitted molybdenum materials remained in the Government stockpile. The revised stockpile goals announced in October 1976 by the Federal Preparedness Agency (FPA) of GSA did not include molybdenum materials. Shipments from the stockpile during the year totaled 1,594,378 pounds of excess molybdenum, including 1,263,831 pounds in molybdenum disulfide, 257,851 pounds in ferromolybdenum, and 72,696 pounds in molybdenum oxide. GSA reported an inventory of 22,231 pounds of molybdenum in ferromolybdenum at yearend 1976.

[1]Physical scientist, Division of Ferrous Metals.

Table 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Concentrate:					
Production	112,138	115,859	112,011	105,980	113,233
Shipments	102,197	135,097	118,163	105,170	114,527
Value	$170,530	$217,721	$234,658	$259,328	$333,494
Consumption	62,560	82,477	91,706	90,046	84,966
Imports for consumption	385	458	155	2,567	2,093
Stocks, Dec. 31: Mine and plant	45,243	21,998	18,659	10,680	9,390
Primary products:					
Production	64,841	85,046	88,509	r87,501	83,970
Shipments	75,538	108,687	114,799	89,789	99,144
Consumption	45,558	57,049	63,476	51,743	50,448
Stocks, Dec. 31: Producers	28,898	22,387	16,078	22,863	13,210
World: Production	r174,813	r180,088	r185,568	r176,713	191,287

rRevised.

DOMESTIC PRODUCTION

Reported domestic mine output of molybdenum increased by 7.3 million pounds, or 6.8% over that of 1975. Production from primary molybdenum ores totaled 75.2 million pounds, 6.4% higher than in 1975. Production from byproduct molybdenum sources, which are predominantly copper porphyry ores, totaled 38 million pounds, 7.8% higher than in 1975. The amount of molybdenum produced as a byproduct of tungsten and uranium mining operations is normally small and decreased slightly in 1976.

Molybdenum ores were mined in Colorado at the Climax and Henderson mines, both owned by AMAX Inc., and in New Mexico at the Questa mine, owned by Molycorp Inc. A record production of nearly 61 million pounds of molybdenum was attained by underground and open pit operations at the Climax mine. Production of molybdenite (MoS_2) concentrate began in August 1976 at the Henderson mine; output of molybdenum totaled 3 million pounds in 1976 and is scheduled to be approximately 20 million pounds in 1977. Production of molybdenum at the Questa mine also reached a new high of 11.5 million pounds.

Byproduct molybdenum was produced from 14 mines, 12 of which were low-grade copper porphyry deposits. As in previous years, the two major byproduct producers were the Sierrita mine of the Duval Corp., a subsidiary of Pennzoil Co., and the Utah copper mine of Kennecott Copper Corp. Both firms operate other open pit copper mines which produced byproduct molybdenum; together with AMAX Inc., and Molycorp Inc., the four corporations accounted for almost 94% of domestic production. Other producers of byproduct molybdenum included Magma Copper Co., Cyprus Mines Corp., and Anamax Mining Co., all of which operate surface copper mines located in Arizona. Mining, concentrating, and smelting activity at Kennecott's Nevada Mines division near McGill was suspended during 1976 because of escalating costs and environmental mandates. Late in the year, Kennecott announced plans to reopen the copper mine and concentrator during 1977.

The startup of operations at AMAX's Henderson mine near Empire, Colo., was the most significant development in the expansion of molybdenum production capacity during the year. The Henderson orebody was discovered in 1964, and construction of mining, milling, concentrating, and haulage facilities has been in progress over a 10-year period. Designed capacity of 50 million pounds of molybdenum per year is projected for 1980, by which time capital expenditures

Table 2.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	Molybdic oxides[1] 1975	Molybdic oxides[1] 1976	Metal powder 1975	Metal powder 1976	Ammonium molybdate 1975	Ammonium molybdate 1976
Received from other producers	8,194	6,541	9	16	837	923
Gross production during year	94,175	90,884	r3,412	4,461	3,456	2,457
Used to make other products listed here	24,032	25,141	459	622	1,508	1,506
Net production	70,143	65,743	r2,953	3,839	1,948	951
Shipments	71,747	77,300	3,147	4,045	2,074	2,378
Producer stocks, Dec. 31	17,130	10,003	473	448	1,347	752
	Sodium molybdate		**Other[2]**		**Total**	
Received from other producers	41	48	20	43	9,101	7,571
Gross production during year	1,196	1,133	11,403	12,406	113,642	111,341
Used to make other products listed here	127	1	15	101	26,141	27,371
Net production	1,069	1,132	11,388	12,305	r87,501	83,970
Shipments	1,054	1,279	11,767	14,142	89,789	99,144
Producer stocks, Dec. 31	170	71	3,743	1,936	22,863	13,210

rRevised.
[1]Includes technical and purified molybdic oxide and briquets.
[2]Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide, molybdic acid, molybdenum metal, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.

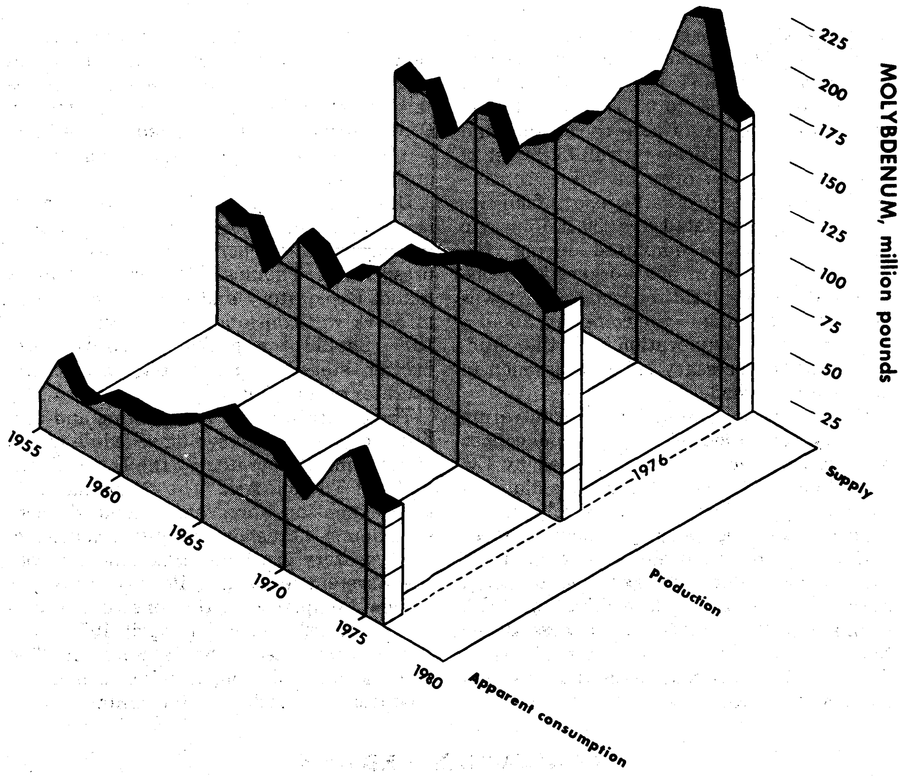

Figure 1.—Apparent consumption, production, and supply of molybdenum in the United States.

on the Henderson facility will approximate $500 million. The project was cited as the Outstanding Engineering Achievement of 1976 by The Northern Chapter of The Professional Engineers of Colorado. Ore reserves approximate 300 million tons averaging 0.49% molybdenite, and account for about 25% of the estimated reserves of molybdenum in the United States.

Startup of the first roaster and a sulfuric acid plant at AMAX's new conversion facility near Fort Madison, Iowa, was scheduled for mid-1977. High-purity molybdic oxide and molybdates were first produced at the plant in 1975. A sulfuric acid plant under construction at AMAX's Langeloth, Pa., conversion facility was nearing completion at yearend.

Questa Molybdenum Co., a partnership formed in 1975 by Molycorp Inc., and Kennecott Copper Corp., announced the results of an exploratory drilling program to delineate additional molybdenite mineralization on Molycorp's Questa property in New Mexico. During 1976, the partnership completed about 130,000 feet of drilling and outlined an estimated 91 million tons of ore with an average grade of 0.34% molybdenite at a 0.20% MoS_2 cutoff. The ore, reported to occur in two separate zones, was thought to be amenable to underground block-caving methods. Additional mineralization was also indicated within the outlined zones and in another area on the Questa property. A feasibility study was conducted to evaluate mining programs and to make cost estimates for production from the newly outlined ore zones. The feasibility study and further exploratory work are expected to be completed by mid-1977. An operating program which would produce 300 million pounds of molybdenum in concentrate over a 15-year period reportedly is necessary if Kennecott continues in the partnership for a production phase.

The discovery of a substantial molybdenum deposit in the Ketchikan area of southeastern Alaska was made by the U.S. Borax

& Chemical Corp., a subsidiary of Rio Tinto-Zinc Corp., Ltd. The ore body was reported to have a potential size of 100 million short tons grading 0.20% to 0.35% molybdenite. Mineralization is at or near the surface and thus amenable to open pit mining. Cost of construction of an open pit mine, concentrating plant, and other support facilities was initially estimated at $250 million. Up to 1,000 would be employed during construction, and about 500 workers would be required once full-time operation was reached. According to the company, about 3 years of further exploration and other studies would be necessary before a decision to mine could be made.

Expansion of mining and concentrating capacity continued at the open pit copper mine near Bagdad, Ariz., operated by Cyprus Bagdad Copper Co., a subsidiary of Cyprus Mines Corp. A 5,800 ton-per-day concentrator has been producing copper and molybdenum concentrates at the mine. The new concentrator, expected to begin operating during the latter half of 1977, would have the capacity to process 40,000 tons per day. Future production of byproduct molybdenum could exceed 1.2 million pounds per year. The company reported that exploratory drilling at the Bagdad deposit encountered additional mineralization but that further work would be necessary to determine its economic importance. Proven reserves at the Bagdad mine totaled 300 million tons of copper-molybdenum ore at the end of 1976.

During 1976, Cyprus Mines Corp. began negotiations on a joint-venture agreement to develop and operate its molybdenum prospect at Thompson Creek in central Idaho. Exploratory and other developmental work will continue on the prospect into 1977. Should the project reach the production stage, Cyprus would become the operator of the mine.

The construction of new mining and milling facilities progressed on schedule at the Sierrita mine, operated by the Duval Corp., south of Tucson, Ariz. The major facets of the expansion program included construction of a crusher building to house two new gyratory crushers, a 2.8-mile ore conveyor system, and a 1.5-mile waste conveyor system. Completion of the construction program was scheduled for April 1977, at a total cost reported to be $30.6 million. The Sierrita open pit copper mine is a major producer of byproduct molybdenum.

CONSUMPTION AND USES

The quantity of molybdenum in concentrate consumed by roasting to produce technical-grade molybdic oxide decreased by 5.1 million pounds and was 5.6% less than in 1975. Some molybdenum concentrate was purified to lubrication-grade molybdenum disulfide, and a small amount was added directly to iron and steel furnaces. Molybdic oxide, the primary form of molybdenum produced at conversion plants, was consumed directly in end-use applications or converted to other molybdenum materials such as ferromolybdenum, molybdates, or metal powder.

Total reported end-use consumption of molybdenum materials decreased 1.3 million pounds, 2.5% below that of 1975 and 20.5% below the record high established in 1974. On the other hand, apparent domestic consumption increased to 59.8 million pounds, 8.6% higher than that of 1975. According to most industry accounts, worldwide demand was strong relative to 1975, and some consumers reported difficulty in obtaining certain molybdenum materials.

The decrease in reported consumption of molybdenum was predominantly due to reduced usage of molybdic oxide and ferromolybdenum in steel production. For all categories of steel output, molybdenum consumption decreased 3.5 million pounds, or 9.3%, compared with that of 1975. The only steel category in which molybdenum use increased was that of tool steels. The steel industry accounted for 67% of the total molybdenum consumed domestically in 1976, down from 72% in 1975.

Aside from steels, consumption of molybdenum increased in most of its other end-use applications. Compared with 1975, consumption of molybdenum in metal mill products increased 60% to 3.3 million pounds; in superalloys, 17% to 2.7 million pounds; and in chemical and ceramic uses, 24% to 4.2 million pounds. Use of molybdenum in the production of cast irons increased marginally.

Table 3.—Consumption of molybdenum materials, by end use in 1976

(Thousand pounds of contained molybdenum)

End use	Molybdic oxides	Ferro-molyb-denum[1]	Ammo-nium and sodium molyb-date	Other molyb-denum materials[2]	Total
Steel:					
Carbon	1,512	299	--	49	1,860
Stainless and heat resisting	4,915	1,256	--	168	6,339
Full alloy	18,795	1,337	--	107	20,239
High-strength low-alloy	1,956	366	--	10	2,332
Electric	115	4	--	--	119
Tool	2,261	757	--	19	3,037
Cast irons	781	3,358	--	142	4,281
Superalloys	1,222	290	--	1,219	2,731
Alloys (excludes steels and superalloys):					
Welding and alloy hard-facing rods and materials	--	348	--	63	411
Other alloys[3]	98	575	--	90	763
Mill products made from metal powder	--	--	--	3,285	3,285
Chemical and ceramic uses:					
Pigments	660	--	599	7	1,266
Catalysts	1,523	--	320	--	1,843
Other	85	27	34	959	1,105
Miscellaneous and unspecified	226	118	58	435	837
Total	34,149	8,735	1,011	6,553	50,448
Consumer stocks, Dec. 31	6,958	1,501	183	1,235	9,877

[1]Includes calcium molybdate.
[2]Includes purified molybdenum disulfide, molybdenite concentrate added directly to steel, molybdenum metal powder, molybdenum metal, pellets, and other molybdenum materials.
[3]Includes magnetic and nonferrous alloys.

STOCKS

Total industry stocks of molybdenum decreased significantly during 1976 reflecting heightened worldwide demand. At yearend, stocks of molybdenum totaled 32.5 million pounds, or about 20% less than at the close of 1975. Especially marked was the drop in stocks of molybdenum contained in products at conversion plants. During the year, inventories of molybdenum at conversion plants decreased from 22.9 million pounds to 13.2 million pounds, the lowest level in about 10 years. Stocks of molybdenum in concentrate at mines and plants also decreased, from 10.7 to 9.4 million pounds during the year. The trend in consumer inventories of molybdenum was in the opposite direction, rising from 6.8 to 9.9 million pounds by the close of 1976. The increase in consumer inventories reflected the growth in demand for molybdenum during the year and, according to some accounts, a degree of hedge buying in anticipation of later price increases.

PRICES

During 1976, the quoted prices for molybdenum concentrate and other molybdenum products were increased three times, on each occasion by 8% to 10%. The price of molybdenum per pound contained in concentrate began the year at $2.62, and was raised to $2.90 in March, to $3.20 in August, and to $3.45 in December. The weighted average price for the year was $2.94 per pound of contained molybdenum. Higher operating expenses, the need to recover the cost of expanding productive capacity, and increasing demand were cited as factors in the price increases. At yearend, the published prices of products per pound of contained molybdenum were as follows:

Climax concentrate	$3.45
Byproduct concentrate	3.25-3.45
Climax oxide/cans	3.82
Dealer oxide	4.10-4.20
K-1 oxide/cans	3.82
K-2 oxide/cans	3.75
Ferromolybdenum/Climax lump	4.43
Ferromolybdenum/Climax powder	4.49
Ferromolybdenum/dealer export	4.60-4.75

FOREIGN TRADE

Exports.—Exports of molybdenum in concentrate and oxide totaled 62.5 million pounds, compared with 62.6 million pounds in 1975. However, because of the higher average prices during the year, the value of exports increased to $183.5 million, 15% higher than in 1975. Foreign shipments of concentrate and oxide represented 55% of domestic production during the year. As in 1975, the Netherlands, Japan, West Germany, and Belgium-Luxembourg were the major countries of destination, receiving 87% of the oxide and concentrate exported.

Exports of ferromolybdenum amounted to 3.6 million pounds, 60% greater than in 1975. Japan, the Netherlands, and India received 49% of the ferromolybdenum exported. The total value of ferromolybdenum exported was $9.4 million, almost twice that of 1975.

Other exports of molybdenum products and their value were metal and alloys in crude form and scrap, $390,000; wire, $3.7 million; powder, $136,000; and semifabricated forms, $1.6 million. The total value of these exports did not vary appreciably from that of 1975; however, their combined gross weight decreased 19% to 775,000 pounds.

Imports.—Molybdenum materials imported during 1976 included concentrate, ferromolybdenum, metal products, and chemicals. Since the United States is self-sufficient in molybdenum materials, the quantity of these imports was only a minor component of domestic supply. Molybdenum concentrate, the major form of imported molybdenum and received only from Canada, continued at the relatively high level of 1975 compared with previous years. During 1976, the molybdenum contained in concentrate imports totaled 2,092,623 pounds with a value of $4.8 million. The average declared value of concentrate imports was $2.32 per pound of contained molybdenum, considerably below the average domestic price of $2.94.

Other molybdenum materials imported included ferromolybdenum containing 7,173 pounds of molybdenum valued at $27,644, also supplied exclusively by Canada. Wrought molybdenum metal with a gross weight of 63,500 pounds and valued at $705,274 was imported from seven countries. Austria supplied 96% of the wrought metal, while Sweden, Austria, and West Germany supplied unwrought metal, containing 72,608 pounds of molybdenum and valued at $138,700. Waste and scrap containing 297,554 pounds of molybdenum valued at $1,183,037 were imported from seven countries. The Netherlands, West Germany, Austria, and Australia were the major suppliers. Imported material in which the chief value was molybdenum came from Canada and Japan and contained 34,083 pounds of molybdenum valued at $70,570.

Imports of molybdenum orange totaled 665,821 pounds (gross weight), valued at $599,273. Canada was the origin of 89% of the molybdenum orange. Unspecified compounds and mixtures in which the chief value was molybdenum were imported from eight countries and contained 27,858 pounds of molybdenum valued at $405,162. Italy, West Germany, and Canada were the major sources of these materials.

Table 4.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds of contained molybdenum)

Product	1975	1976
Molybdenite concentrate	36,618	30,935
Molybdic oxide	31,210	29,644
All other primary products	1,874	2,152

Table 5.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by country

(Thousand pounds of contained molybdenum and thousand dollars)

Country	1975		1976	
	Quantity	Value	Quantity	Value
Argentina	45	95	165	615
Australia	--	--	39	154
Austria	87	247	87	259
Belgium-Luxembourg	11,156	28,820	6,871	21,210
Brazil	950	2,507	241	761
Canada	1,157	2,717	373	856
France	820	2,265	396	1,169
Germany:				
East	--	--	11	69
West	6,398	14,746	8,049	21,245
India	167	462	461	1,465
Italy	109	294	43	110
Japan	9,217	25,107	11,748	35,401
Korea, Republic of	1	4	48	72
Mexico	1,492	2,642	881	2,076
Netherlands	26,131	67,645	27,987	85,102
New Zealand	11	28	3	14
Philippines	15	41	1	2
South Africa, Republic of	159	377	75	198
Spain	93	152	102	196
Sweden	1,852	4,427	2,748	7,173
Switzerland	145	373	442	1,223
United Kingdom	2,520	6,264	1,096	2,702
Venezuela	77	359	599	1,437
Other	r9	r20	8	27
Total	62,611	159,592	62,474	183,536

rRevised.

Table 6.—U.S. exports of molybdenum products

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1975		1976	
	Quantity	Value	Quantity	Value
Ferromolybdenum:[1]				
Argentina	76	216	213	616
Australia	240	538	177	393
Belgium-Luxembourg	--	--	121	482
Brazil	3	5	14	36
Canada	594	929	284	674
Colombia	16	33	17	41
India	114	264	369	999
Italy	214	487	--	--
Japan	445	1,090	871	1,921
Mexico	161	420	--	--
Netherlands	52	122	519	1,438
Peru	4	16	--	--
Philippines	--	--	7	16
South Africa, Republic of	127	301	261	723
Spain	22	52	255	858
Sweden	95	214	289	720
Switzerland	--	--	110	340
Taiwan	11	23	7	16
Turkey	24	17	--	--
United Kingdom	43	71	80	169
Other	--	--	2	5
Total	2,241	4,798	3,596	9,447
Metal and alloys in crude form and scrap:				
Canada	18	4	--	--
France	--	--	1	2
Germany, West	56	187	116	144
Japan	76	221	35	144
Mexico	20	67	10	10
South Africa, Republic of	48	88	--	--
Switzerland	51	89	--	--
United Kingdom	44	185	59	78
Other	4	17	2	12
Total	317	858	223	390

See footnotes at end of table.

Table 6.—U.S. exports of molybdenum products —Continued

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Wire:				
Argentina	2	33	5	67
Australia	6	55	11	84
Belgium-Luxembourg	9	66	14	110
Brazil	15	237	27	440
Canada	51	508	58	502
France	19	202	34	333
Germany, West	77	623	89	820
India	(2)	4	2	17
Israel	7	44	--	--
Italy	6	50	13	133
Japan	35	274	50	434
Mexico	6	143	9	175
Netherlands	5	185	--	--
Philippines	(2)	10	(2)	7
Singapore	4	86	3	256
Spain	12	83	14	113
United Kingdom	12	213	10	125
Other	4	47	4	56
Total	270	2,863	343	3,672
Powder:				
Australia	(2)	3	1	7
Canada	7	28	2	15
Germany, West	14	51	4	16
Italy	2	12	--	--
Japan	(2)	2	5	13
Mexico	2	9	6	37
Spain	(2)	7	--	--
Sweden	28	157	5	30
Switzerland	(2)	7	--	--
United Kingdom	5	14	(2)	2
Other	r2	r6	2	16
Total	60	296	25	136
Semifabricated forms, n.e.c.:				
Australia	1	12	7	28
Belgium-Luxembourg	(2)	8	(2)	11
Brazil	2	26	2	22
Canada	19	198	6	75
France	18	150	10	173
Germany, West	28	208	29	420
Honduras	79	38	--	--
India	9	36	--	--
Italy	3	61	2	27
Japan	5	65	18	329
Korea, Republic of	--	--	2	35
Mexico	67	158	2	26
Netherlands	6	134	4	92
South Africa, Republic of	28	234	5	48
Sweden	(2)	37	(2)	8
Taiwan	(2)	1	76	8
United Kingdom	42	374	14	179
Other	5	50	7	103
Total	312	1,790	184	1,584

rRevised.
[1]Ferromolybdenum contains about 60% to 65% molybdenum.
[2]Less than 1/2 unit.

Table 7.—U.S. import duties

Item	Article	Rate of duty, Jan. 1, 1977[1]
601.33	Molybdenum ore	12 cents per pound on molybdenum content.
603.40	Material in chief value molybdenum	10 cents per pound on molybdenum content plus 3% ad valorem.
607.40	Ferromolybdenum	Do.
	Molybdenum:	
628.70	Waste and scrap	10.5% ad valorem.[2]
628.72	Unwrought	10 cents per pound on molybdenum content plus 3% ad valorem.
628.74	Wrought	12.5% ad valorem.
	Molybdenum chemicals:	
417.28	Ammonium molybdate	10 cents per pound on molybdenum content plus 3% ad valorem.
418.26	Calcium molybdate	Do.
419.60	Molybdenum compounds	Do.
420.22	Potassium molybdate	Do.
421.10	Sodium molybdate	Do.
423.88	Mixtures of inorganic compounds, chief value molybdenum	Do.
473.18	Molybdenum orange	5% ad valorem.

[1]Not applicable to countries that have centrally controlled economies.
[2]Duty on waste and scrap temporarily suspended.

WORLD REVIEW

World production of molybdenum was estimated at 191.3 million pounds, or about 14.6 million pounds higher than that of 1975. On a worldwide basis, about half the molybdenum produced was as a byproduct, chiefly from copper mining operations. Among market economy countries, the United States, Canada, and Chile continued as the major producers of molybdenum. Although mine production of molybdenum in the U.S.S.R. must be estimated, it was the major producer among central economy countries. The People's Republic of China was probably a significant producer of molybdenum also, but it has been omitted from the table of world production due to lack of data on which to base a reliable estimate of its mine output.

Argentina.—If undertaken, development of the El Pachón copper-molybdenum deposit would take at least 4 years with initial production in 1981. An estimated $750 million would be needed to finance the development, according to its owners, Cia. Minera Aguilar, S.A., a subsidiary of St. Joe Minerals Corp. Exploratory work completed as of mid-1976 established about 860 million tons of ore, grading 0.59% copper and 0.016% molybdenum. Facilities for extracting molybdenum would be included in the mining complex.

Brazil.—The Brazilian Government announced the discovery of a molybdenum deposit in the northern territory of Roraima. The discovery was the first significant deposit of molybdenum found in Brazil. Although no estimate of the deposit's size was given, preliminary tests indicated a possible ore grade of 1% molybdenum or higher.

Canada.—Craigmont Mines, Ltd., began an exploratory drilling program on the Carmi molybdenum property located in southern British Columbia. Drilling commenced soon after Craigmont optioned the property from Vestor Explorations, Ltd., in May. Previous drilling on the property had outlined two mineralized zones with a total reserve estimated at 40 million tons of ore grading 0.15% molybdenite. Both zones were undefined laterally and to depth. The drilling undertaken by Craigmont later in the year resulted in the finding of additional mineralized zones. Considerable further exploration was planned in order to define more fully the extent and grade of the deposits.

Noranda Mines Ltd., announced that an additional $900,000 would be spent on drilling and other development work in order to evaluate the possibility of open pit mining at its Boss Mountain molybdenum mine near Hendrix Lake, British Columbia. According to Noranda, the property appeared to have the potential to support a 20,000-ton-per-day milling operation of low-grade surface material. The company stated that a pilot plant stage of ore testing might be necessary to confirm metallurgical findings. Higher grade ore, which was being worked by underground methods, was reported to be sufficient to sustain current operations until the end of 1977.

The Noranda Exploration Co., Ltd., was given an option to explore the Ruby Creek molybdenum prospect in northern British Columbia by Adanac Mining and Exploration, Ltd. The property had been explored previously by Climax Molybdenum Corp. of British Columbia, Ltd. The Ruby Creek property is reported to contain about 104 million tons of ore grading 0.16% molybdenite.

Midas Resources, Ltd., obtained an option on 10 copper-molybdenum claims in Powell Township, near Matachewan, Ontario. Mineralization was reported to be intermittently exposed over a distance of approximately 500 feet in length. The company planned to conduct exploration and survey work on the claims.

Chile.—It was announced that financing of a new molybdenum conversion plant would be provided by the Chilean Copper Workers Federation, the Inter-American Development Bank, and Chile's Central Bank. The plant will have facilities for converting molybdenum concentrate to molybdic oxide and ferromolybdenum. After the plant becomes operational, exports of the higher priced oxide and ferromolybdenum will be increased, thus generating additional foreign exchange revenue for Chile.

Iran.—Development of the Sar Cheshmeh copper-molybdenum porphyry deposit in south-central Iran continued, but scheduled initial production has been delayed, possibly to late 1977. Reasons cited for the delay include late deliveries of necessary equipment, setbacks in worker training programs, and a considerable increase in capital cost of the project to over $1 billion from an original estimate of $430 million. The mining facility will include a molybdenum recovery plant and a smelter to produce blister copper at an initial rate of about 160,000 tons per year. Expected output of molybdenum has not yet been reported. However, reserves are presently estimated to total about 470 million tons of ore with an average grade of 1.12% copper and 0.03% molybdenum.

Mexico.—Startup of milling and concentrating operations at the La Caridad copper-molybdenum porphyry deposit was scheduled for late 1977. The mine, located in the State of Sonora about 200 miles northeast of Hermosillo, is operated by Mexicana de Cobre S.A., a company owned by the Mexican Government and private Mexican interests. Work at the mine site during 1976 consisted of a preproduction stripping program, construction of crusher and concentrator plants, and operation of a 100 ton-per-day pilot plant to test mill design circuitry. Various methods of molybdenum recovery were studied in the pilot plant. When operational, the concentrator will initially treat about 80,000 tons of ore per day.

Papua New Guinea.—A consortium was formed by Broken Hill Pty. Co. Ltd., of Australia with the Government of Papua New Guinea and mining interests from the United States and West Germany to undertake a feasibility study of the Ok Tedi copper deposit. Drilling completed by mid-1976 established an orebody of at least 275 million tons with an average of 0.85% copper, 0.012% molybdenum, and some gold values. The study should take about 2 years, and if mine development is warranted, production may be possible by 1983.

Molybdenum mineralization was reported by Triako Mines N.L. at the Yandera copper prospect. Exploratory drilling completed in early 1976 outlined indicated reserves of 124 million tons and inferred reserves of 214 million tons grading 0.42% copper and about 0.02% molybdenum, with gold and silver values. Additional mineralization was found but had not been adequately explored for reserve calculations. The company and its associates, Buka Minerals N.L. and a Kennecott Copper Corp. unit, were evaluating exploration data in consideration of further exploratory work.

Peru.—Production of concentrates began in July 1976 at the Cuajone copper-molybdenum mine operated by Southern Peru Copper Corp. (SPCC). Full production capacity of 170,000 tons of copper in concentrate per year was nearly reached by yearend. The open pit mine site, concentrator, and auxiliary facilities required 6 years of development work at an approximate cost of $730 million. The Caujone project is a joint venture of SPCC, a consortium of U.S. mining companies, and Billiton N.V., a subsidiary of the Royal Dutch / Shell Group. Billiton's equity is about 11.5% of the total investment. The mine is located at an elevation of about 12,000 feet within 15 miles of SPCC's previously operating Toquepala open pit copper-molybdenum mine. A rail line connects the two mines and runs to the southern coastal town of Ilo where the company's newly enlarged smelter is located. The Cuajone orebody contains reserves of 470 million tons of ore with approximately 1% copper and 0.03% molybdenum.

Table 8.—Molybdenum: World mine production by country

(Thousand pounds contained molybdenum)

Country[1]	1974	1975	1976[p]
Australia[e]	25	25	25
Canada (shipments)	30,736	28,719	31,780
Chile	21,466	20,042	24,028
Japan	235	309	[e]330
Korea, Republic of	166	166	264
Mexico	95	37	35
Peru	[r]1,434	1,435	992
Portugal	(2)	--	--
U.S.S.R.[e]	19,400	20,000	20,600
United States	112,011	105,980	113,233
Total	[r]185,568	176,713	191,287

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, Bulgaria, North Korea, Nigeria, the People's Republic of China, and Romania are believed to produce molybdenum, but information is inadequate to make reliable estimates of output levels.

[2]Less than 1/2 unit.

TECHNOLOGY

During 1976, research programs in general were directed towards improved methods of molybdenum recovery at ore concentrating facilities and new end-use applications for molybdenum materials.

Bureau of Mines investigators described an electrooxidation process to recovery molybdenum and rhenium from offgrade concentrates.[2] The process consisted of dissolution of metal values by electrooxidation, liquid-solid separation by thickening, acidification and chlorate ion removal by sulfur dioxide treatment, solvent extraction to concentrate the molybdenum and rhenium, separation of the two metals by carbon adsorption, and metal recovery by crystallization. An offgrade molybdenite concentrate containing about 36% molybdenum and 1,330 parts per million (ppm) of rhenium was used to test the process. Extraction of about 99% of both metals was obtained by electrooxidation with an energy consumption of 13.7 kilowatt-hours per pound of molybdenum extracted. After separation of the two metals using a carbon adsorption column, the final recovery of molybdenum and rhenium was 96% to 98%.

Pilot-scale demonstration of the electrooxidation process was successfully completed during the year at the Nevada Mines Division of Kennecott Copper Corp. near McGill, Nev. Extraction of 94% to 98% of molybdenum and rhenium was routinely achieved from offgrade concentrates produced by the concentrator at the mine site.

A steam injection method for flotation separation of molybdenum from copper sulfide concentrate developed by the Bureau of Mines was tested at the Mineral Park property in Arizona owned by the Duval Corp. Steam injection prior to and during flotation resulted in a higher grade of molybdenum in rougher concentrate and greater copper rejection.

Bureau of Mines researchers were also engaged in a project to decrease the molybdenum content of waste waters from ore-processing operations at the Questa mine owned by Molycorp Inc. An ion exchange technique which reduced the molybdenum concentration in waste water from 4 ppm to 0.3 ppm was developed. A technique which involved coprecipitation of molybdenum with ferric hydroxide was also evaluated.

The results of numerous metallurgical studies of molybdenum-containing steels and alloys were published during the year. A standard constructional steel (SAE 4135), modified by increasing the molybdenum content and adding columbium, was tested for the effects of various production variables on its mechanical properties and sulfide stress cracking (SSC) resistance.[3] Steels with high strength and high SSC resistance, such as this modified SAE 4135, are required for casing, tubing, and tool joints used in the drilling of and production from deep oil and gas wells where hydrogen sulfide or "sour gas" is encountered. Among the conclusions reached by the cited study were that the SSC resistance of the modi-

[2]Scheiner, B. J., R. E. Lindstrom, and D. L. Pool. Extraction and Recovery of Molybdenum and Rhenium From Molybdenite Concentrates by Electrooxidation: Process Demonstration. BuMines RI 8145, 1976, 12 pp.

[3]Grobner, P. J., D. L. Sponseller, and D. E. Diesburg. The Effects of Processing Variables on Mechanical Properties and Sulfide Stress Cracking Resistance of SAE 4135 Steel Modified With 0.75 Percent Mo and 0.035 Percent Cb. J. Eng. for Ind., v. 98, No. 2, May 1976, pp. 708-716.

fied steel was clearly greater than that of unmodified SAE 4130 steel and that this advantage in SSC resistance increased with greater hardness and yield strength of the steel.

A group of highly alloyed, austenitic stainless materials were examined for their applicability in the high-pressure, high-temperature, and corrosive environments encountered in deep gas wells.[4] The study identified certain of these materials which performed well on tests for sulfide stress cracking, chloride stress corrosion cracking, pitting, crevice corrosion, and general weight-loss corrosion performance in the absence of a corrosion inhibitor. The inert alloys that exhibited high resistance in all of the tests contained 7% to 15% molybdenum in addition to 55% to 70% nickel plus cobalt and 15% to 20% chromium.

The corrosion-resistant properties and applications of ferritic stainless steels, several of which contain molybdenum as a vital alloying element, were reviewed.[5] Several of the newer ferritic stainless steels, containing 1% to 4% molybdenum, combine resistance to chloride stress corrosion cracking with better weldability than established ferritic grades. The production of these steels has become possible with the development of new production processes such as argon-oxygen decarburization (AOD), electron-beam melting, and vacuum induction melting.

The use of soluble molybdates as corrosion inhibitors in cooling water systems was described.[6] When used at low concentration levels with other soluble corrosion inhibitors, molybdate-containing formulations were shown to be effective in both low- and high-hardness water systems and to be cost competitive with established water treatments. The very low toxicity of soluble molybdates makes their usage desirable from an environmental standpoint.

The addition of soluble molybdate was also found to retard corrosion of SAE 1010 steel in aerated solutions containing chloride and sulfate.[7] Electrochemical tests were also performed in order to study the behavior and mechanism of the molybdate ion as a corrosion inhibitor.

Other areas that experienced considerable technological interest during the year included the use of purified molybdenum disulfide as an additive in oils and greases, the application of molybdenum compounds as flame retardants and smoke suppressants, the development of molybdenum monocarbide as a potential substitute for tungsten carbide in cutting tools and high-speed steels, and the recycling of molybdenum catalysts used in petroleum refining.

U.S. patents granted during 1976 that dealt with the processing of molybdenum materials included ones for purification of technical-grade molybdenum oxide by mixing with sulfuric acid, roasting, and leaching with ammonium hydroxide;[8] for the extraction of molybdenum values from an ore leach solution with an organic solvent;[9] for the separation of tungsten and molybdenum from an alkaline leach solution;[10] for the production of molybdenum trioxide by roasting molybdenite concentrate in a recirculating fluidized bed reactor;[11] for the purification of molybdenum oxide by reroasting and formation of soluble molybdates;[12] for the production of molybdenum metal by direct dissociation of molybdenite;[13] for the carbonyl extraction of molybdenum and other metal values from low-grade ore, filter cake, or mine tailings;[14] for the recovery of molybdenum from a leach solution containing tungsten by oxidation of molybdic acid ions and the precipitation as molybdenum sulfide;[15] for the purification of molybdenite concentrate by treatment with hydrofluoric and sulfuric acids;[16] for the extraction of molybdenum from mo-

[4]Watkins, M., and J. B. Greer. Corrosion Testing of Highly Alloyed Materials for Deep, Sour Gas Well Environments. J. Petrol. Technol., June 1976, pp. 698-704.

[5]Lula, R. A. Ferritic Stainless Steels - Corrosion Resistance + Economy. Metal Prog., v. 110, No. 2, July 1976, pp. 24-29.

[6]Robitaille, D. R., and J. G. Bilek. Molybdate Cooling Water Treatments. Chem. Eng., v. 83, No. 27, Dec. 20, 1976, pp. 77-80.

[7]Lizlovs, E. A. Molybdates as Corrosion Inhibitors in the Presence of Chlorides. Corrosion, v. 32, No. 7, July 1976, pp. 263-266.

[8]Vertes, M. A., and R. A. Ronzio (assigned to AMAX Inc.). Purification of Technical Grade Molybdenum Oxide. U.S. Pat. 3,932,580, Jan. 13, 1976.

[9]Baucom, E. I. (assigned to E. I. du Pont de Nemours & Co.). Extraction of Molybdenum Values. U.S. Pat. 3,933,971, Jan. 20, 1976.

[10]Bellingham, A. I. (assigned to Warman Equipment Ltd.). Separation of Tungsten and Molybdenum Occurring Together in a Solution. U.S. Pat. 3,939,245, Feb. 17, 1976.

[11]Wilkomirsky, I. A., A. P. Watkinson, and J. K. Brimacombe (assigned to Canadian Patents and Development Ltd.) Production of Molybdenum Trioxide in a Fluidized Bed Reactor. U.S. Pat. 3,941,867, Mar. 2, 1976.

[12]Ronzio, R. A., R. C. Ziegler, F. N. Oberg, and R. S. Rickard (assigned to AMAX Inc.). Purification of Molybdenum Oxide Concentrate. U.S. Pat. 3,957,946, May 18, 1976.

[13]Buker, D. O. (assigned to AMAX Inc.). Production of Molybdenum Metal. U.S. Pat. 3,966,459, June 29, 1976.

[14]Bakker, L. (assigned in part to J. P. Meyers). Carbonyl Extraction of Molybdenum. U.S. Pat. 3,966,886, June 29, 1976.

[15]Onozaki, S., S. Nemoto, and T. Hazeyama (assigned to Nittetsu Mining Co., Ltd.). Recovery of Tungsten and Molybdenum Values From an Alkaline Solution. U.S. Pat. 3,969,484, July 13, 1976.

[16]Ronzio, R. A., J. G. Brown, and R. C. Ziegler (assigned to AMAX Inc.). Purification of Molybdenite Concentrate. U.S. Pat. 3,991,156, Nov. 9, 1976.

lybdenite concentrate by reaction under pressure with nitric acid to form molybdic acid;[17] for the direct production of molybdenum or other metal powders from oxides or roasted sulfide ores by processing in an arc heated plasma gas;[18] and for an induced polarization method to locate and indentify underground disseminated deposits of sulfide ores of molybdenum and other metals.[19]

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[17]Mollerstedt, B. O. P., and K. E. Backius (assigned to Molyscand A. B.). Hydrometallurgical Extraction of Molybdenum From Molybdenite. U.S. Pat. 4,000,244, Dec. 28, 1976.

[18]Fey, M. G., and E. A. Dancy (assigned to Westinghouse Electric Corp.). Direct Production of Molybdenum, Tungsten, Columbium, or Tantalum Powder in an Arc Heated Plasma Gas. U.S. Pat. 3,989,511, Nov. 2, 1976.

[19]Zonge, K. L. Induced Polarization Method for Locating and Identifying Major Features of Underground Disseminated Deposits. U.S. Pat. 3,967,190, June 29, 1976.

Natural Gas

By Gordon W. Koelling[1] and Leonard L. Fanelli[2]

Marketed production of natural gas in the United States declined 0.8% to 20.0 trillion cubic feet (Tcf) in 1976.[3] Although this was the third consecutive annual decrease in production, the rate of decline was considerably less than that registered during the 2 previous years.

Total consumption of natural gas (including extraction loss) increased 1.9% to 20.8 Tcf during 1976 in conjunction with the persistence of considerably lower than normal temperatures in most of the country east of the Rocky Mountains from October through yearend. Residential and commercial use of natural gas increased 2.6% and 5.0%, respectively, and consumption by the industrial sector, the largest user, declined slightly. The electric utilities sector registered a 2.2% decline.

Table 1.—Salient statistics of natural gas in the United States

	1972	1973	1974	1975	1976
Supply:					
Marketed production[1] million cubic feet	22,531,698	22,647,549	21,600,522	20,108,661	19,952,438
Withdrawn from storage do	1,757,218	1,532,820	1,700,546	1,759,565	1,921,017
Imports do	1,019,496	1,032,901	959,284	953,008	963,768
Total do	25,308,412	25,213,270	24,260,352	22,821,234	22,837,223
Disposition:					
Consumption do	23,009,445	22,965,914	22,110,623	20,409,875	20,800,582
Exports do	78,013	77,169	76,789	72,675	64,711
Stored do	1,892,952	1,974,324	1,784,209	2,103,619	1,755,690
Adjustments[2] do	328,002	195,863	288,731	235,065	216,240
Total do	25,308,412	25,213,270	24,260,352	22,821,234	22,837,223
Value at wellhead:					
Total thousand dollars	4,180,462	4,894,072	6,573,402	8,945,062	11,571,776
Average cents per thousand cubic feet	18.6	21.6	30.4	44.5	58.0

[1]Marketed production of natural gas represents gross withdrawals less gas used for repressuring and quantities vented and flared.
[2]Includes transmission losses, changes in aboveground storage and gas unaccounted for.

NOTE.—Domestic production as used in the Bureau publication "Minerals and Materials/monthly survey" represents marketed production less the shrinkage (extraction loss) resulting from the extraction of natural gas liquids.

Proved reserves of natural gas declined 5.3% from 228.2 Tcf at yearend 1975 to 216.0 Tcf by yearend 1976 as annual discoveries failed to equal production for the eighth time in the last 9 years. Extensions to known fields during 1976 totaled 5.3 Tcf, and new reservoir discoveries in old fields and new field discoveries accounted for 3.4 Tcf. Revisions of previous reserve estimates and changes in underground storage resulted in a net reduction of 1.4 Tcf.

The average wellhead value of natural gas increased 30.3% to 58.0 cents per thousand cubic feet (Mcf) in 1976. During the same year the average retail price for gas delivered to consumers rose 22.8% to 146.5 cents per Mcf.

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[1]Mineral Specialist, Division of Petroleum and Natural Gas.
[2]Survey Statistician, Division of Fuels Data.
[3]All gas volumes in this chapter are on a pressure base of 14.73 psia at 60° F.

Exports of 65 billion cubic feet (Bcf) in 1976 were 11.0% less than in 1975. Almost 77.0% of total 1976 exports was shipped from Alaska to Japan as liquefied natural gas (LNG). The remaining exports, which were transported by pipeline, were almost equally divided between Canada and Mexico.

Natural gas imports increased 1.1% to 964 Bcf in 1976. Almost all of this gas was shipped from Canada via pipeline. LNG shipments from Algeria totaled approximately 10 Bcf and for the second consecutive year, no imports were received from Mexico.

Efforts to supplement natural gas supplies through the manufacture of synthetic natural gas (SNG) from liquid fuels for peakshaving purposes continued. Twelve SNG plants were operational and one was under construction as of yearend 1976.

Seven pilot projects for the development and testing of processes for the production of high-Btu gas from coal were operational at yearend 1976. An additional four projects involving the production of low-Btu gas from coal were also operational or under construction, and both government and industry were engaged in research involving the output of low-Btu gas from in situ coal gasification. The Bureau of Mines continued its experiment in gathering methane from a West Virginia coal deposit, and in November 1976 entered into a cooperative agreement for testing the use of hydraulic fracturing to stimulate methane recovery from a Pennsylvania coalbed prior to mining. During 1976, several gasification projects involving biomass conversion were also under development.

Research programs involving fracturing techniques to stimulate flow from economically submarginal gas reservoirs were continued during 1976. Most of this activity was in Colorado, Wyoming, Utah, and Texas, but several projects involved efforts to fracture reservoirs in the Upper Devonian Shales of the eastern United States. During 1976, a Government-industry contract was signed for the investigation of methane-saturated gulf coast salt water aquifers.

The Federal Power Commission (FPC) regulates the sale, transportation, and price of gas moved in interstate commerce. During 1976, the FPC increased the uniform national base rate from its previous level of $0.52 per Mcf to $1.42 per Mcf for sales of natural gas from wells commenced on or after January 1, 1975, with an automatic quarterly escalation of $0.01 per Mcf beginning October 1, 1976. A ceiling for natural gas from wells commenced during 1973 and 1974 was set at $0.93 per Mcf, with a $0.01 per annum escalator. Natural gas from wells commenced prior to January 1, 1973, was to be allowed to rise from the previous level of $0.29 per Mcf to $0.52 per Mcf when contracts expire by their own terms.

Leasing of public lands for the exploration and development of natural gas (and crude oil) resources continued under the authority of various public land acts. In 1976, the Federal Government leased a total of 1.3 million acres in the Gulf of Mexico, Gulf of Alaska, and Mid-Atlantic Outer Continental Shelf areas for bonus bids aggregating $2.3 billion.

The Office of Pipeline Safety (OPS), which is responsible for safety regulation of natural gas pipelines, reported that the total number of pipeline failures in 1976, and the fatalities resulting from these failures, were the highest since it began reporting these data pursuant to the Natural Gas Pipeline Safety Act of 1968. Pipeline failures during 1976 were 15% higher than in 1975, and fatalities resulting from these failures jumped from 14 to 63. Damage by outside forces was the cause of 55.6% of total failures in 1976 (table 2).

Federal gas pipeline safety standards, contained in 49 CFR Part 192 of Title 49 of the Code of Federal Regulations, were amended during 1976 to update existing referenced documents, provide protection for buried cast iron pipelines, clarify requirements for operator emergency plants, establish new performance standards for joint sealing methods for cast iron pipe, provide more appropriate bending requirements for steel pipe, and delineate the safety regulations for offshore gas pipelines. Notices of proposed rulemakings were issued with respect to modified corrosion control requirements for small isolated metal fillings in plastic pipelines, modified bending requirements, and occupational safety and health requirements for pipeline personnel.

DOMESTIC PRODUCTION

Gross withdrawals of natural gas; including marketed production, gas returned to the formation for pressure maintenance, and that vented or flared; totaled 20.9 Tcf in 1976, only 0.8% less than in 1975. Marketed production, which totaled 20.0 Tcf in 1976, was also only 0.8% less than during 1975. Gas used for repressuring and quantities vented and flared in 1976 totaled 0.9 Tcf and 0.1 Tcf, respectively, approximately the same as in 1975. Data on gross withdrawals and disposition of natural gas appear in table 3.

Gross withdrawals from gas wells declined 1.1% in 1976 to 17.2 Tcf and gas withdrawals from oil wells increased 0.8% to 3.8 Tcf. Increased gross withdrawals were registered by 20 of the 31 producing States, but the quantities involved in most cases were small. The largest gain, 121 Bcf, was in Oklahoma. Gross production in Texas, the largest producing State, declined 4.0%.

Most of the total marketed natural gas production was from Texas and Louisiana. Marketed production data for leading producing States are shown in the following tabulation:

State	Marketed production in 1976 (Bcf)	Change from 1975 (percent)	Percent of total U.S. marketed production in 1976
Texas	7,192	-3.9	36.0
Louisiana	7,007	-1.2	35.1
Oklahoma	1,727	+7.6	8.7
New Mexico	1,231	+1.2	6.2
Kansas	829	-1.8	4.2
California	354	+11.3	1.8
Wyoming	329	+4.1	1.6
Others	1,283	+4.1	6.4
Total	19,952	-0.8	100.0

Gas well completions (table 4) increased 19.9% to 9,085 in 1976. Approximately 37.6% of the total net increase was accounted for by Ohio, where most of the wells completed were shallow and self-help drilling (drilling by gas consumers on their own property) was also an important factor. Another 29.4% of the total net growth was registered in Louisiana, were the bulk of the increase in completions resulted from in-fill drilling on closer spacing in the northern part of the State in response to rising intrastate gas prices. In Texas, which accounted for 20.0% of the total increase, continuing development of the Laredo field and exploratory and development drilling in the Ozana-Sonora area in the southwest part of the State were partially responsible for increased activity.

Completions of exploratory wells (table 5) in 1976 increased 19.7% to 1,402. Texas accounted for 49.4% of these completions.

Data in gas well completions include condensate wells. The latter are wells that produce from high-pressure natural gas reservoirs, some of which contain considerable quantities of liquid hydrocarbons in the pentanes and heavier range described generically as "condensate."

The number of gas condensate wells producing at yearend 1976 totaled 137,443 (table 6). This was an increase of 4.0% over the 1975 yearend total and 13.4% more than the number of wells producing at yearend 1972.

CONSUMPTION AND USES

Consumption (wet) of natural gas in 1976 totaled 20.8 Tcf, 1.9% higher than in 1975 (table 7). Gas delivered to consumers increased 1.2% to 17.8 Tcf during 1976 when it accounted for 85.4% of total consumption. Of the remainder, 7.9% was used as lease and plant fuel, 2.6% was used for pipeline fuel, and 4.1% was accounted for by extraction losses (shrinkage) at gas-processing plants.

Residential use increased 2.6% in 1976 to 5,051 Bcf when it accounted for 28.4% of the total deliveries to consumers (table 8). Increases in residential use occurred in all census regions except the Pacific and West North Central.

The total number of residential consumers declined slightly during 1976. Data on the number of residential customers by census regions for the years 1966, 1975, and 1976 are as follows:

Census regions	Residential consumers (thousands)		
	1966	1975	1976
New England	1,532	1,626	1,556
Middle Atlantic	7,490	7,594	7,512
East North Central	8,181	9,493	9,453
West North Central	3,001	3,587	3,415
South Atlantic	3,005	3,597	3,493
East South Central	1,679	1,967	1,798
West South Central	4,081	4,698	4,923
Mountain	1,580	2,227	2,184
Pacific	5,535	6,727	6,904
Total	36,084	41,516	41,238

The use of gas by the commercial sector increased 5.0% to 2,383 Bcf in 1976 despite a 1.6% decline in the number of customers. This sector accounted for 13.4% of total deliveries to consumers.

The industrial sector remained the largest user of natural gas, accounting for 39.2% of 1976 deliveries to consumers. Total consumption by this sector declined only slightly to 6,967 Bcf during the year. Most of the gas used by industry was consumed as fuel with petroleum refineries, which used 19 Bcf, comprising the largest fuel-consuming industrial sector. Other important industrial users of gas for fuel included the primary metal, nonmetalic, paper, and food products sectors.

The principal non-fuel use of gas involved the petrochemicals industry. This sector's use of gas as a feedstock in 1976 accounted for 8.7% of total industrial use and 3.4% of all U.S. natural gas consumption. Of the 607 Bcf of natural gas used by the petrochemicals industry as a raw material in 1976, nearly 435 Bcf went into production of ammonia. The second largest use, nearly 75 Bcf, was used for production of methanol. Manufacturers of acetylene, carbon black, and hydrogen were also significant consumers of natural gas for raw material use, collectively accounting for an additional 75 Bcf. Producers of hydrogen cyanide, carbon disulfide, chloroform, methyl chloride, methylene chloride, and carbon tetrachloride accounted for most of the remaining consumption of gas as a raw material.

Use of gas by electric utilities continued to decline in 1976 when consumption by this sector dropped 2.2% to 3,078 Bcf. Decreases occurred in all regions except New England, West South Central, and Pacific, which registered relatively small volume gains.

The continued shortage of natural gas supplies during 1976 forced many gas-distribution companies to deny service to new customers and to curtail supplies to some existing users (tables 10-14). FPC reported that net curtailments of firm delivery commitments of the major interstate pipeline companies for the year April 1976 through March 1977 totaled 3,380 Bcf, a deficiency of 23.0%. Net interruptible curtailments for the same period were reported at 475 Bcf, a deficiency of 70.9%. Firm curtailments for the year ending March 1977 were 20.7% higher than those for the preceding period and interruptible curtailments rose 43.9%.

The mileage of field and gathering, transmission, and distribution pipelines in service at the end of 1976 was up only 0.8% from that of the previous year. Data on the Nation's natural gas pipeline network are as follows, in thousands of miles:

	1964	1974	1975	1976
Field and gathering	61.0	66.4	68.5	70.3
Transmission	205.4	262.2	262.6	258.2
Distribution	469.8	645.6	r648.2	659.1
Total	736.2	974.2	r979.3	987.6

rRevised.

RESERVES

Discoveries of natural gas failed to equal production during 8 of the last 9 years, and proved reserves declined 26% during the period. In 1975, the quantity of gas discovered was considerably less than that produced and proved reserves dropped 5.3% from 228.2 Tcf at yearend 1975 to 216.0 Tcf by yearend 1976 according to the Committee on Natural Gas Reserves of the American Gas Association (AGA).

Net additions, before production, to proved reserves reported in 1976 aggregated almost 7.4 Tcf, approximately 31% less than in 1975. Almost 53% of net additions to reserves in 1976 were offshore in the Gulf of Mexico. Extensions to known fields accounted for the largest addition to reserves, 5.3 Tcf, approximately 52% of which were in Texas and Louisiana (including offshore). About 59% of the 2.0 Tcf total for new

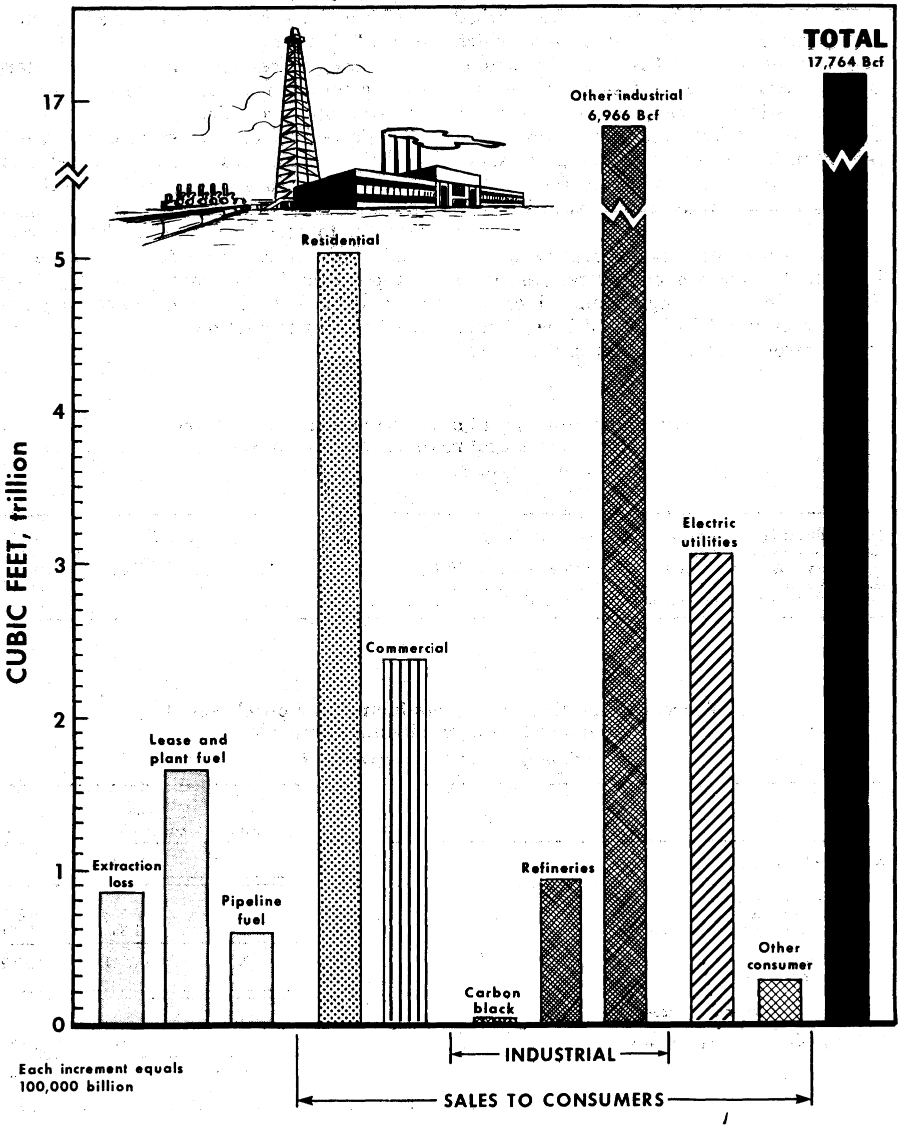

Figure 1.—Disposition of natural gas consumed in the United States, by principal use.

reservoir discoveries in old fields were in Louisiana. New field discoveries totaled approximately 1.4 Tcf, over 68% of which was accounted for by Texas and Louisiana. On the negative side, revisions of previous reserve estimates resulted in a net reduction of 1.2 Tcf, and there was a net reduction in underground storage of about 0.2 Tcf. Details on proved reserves of natural gas in the United States are shown in table 16.

There were some net increases during 1976 in the reserves of natural gas in 11 States. However, significant increases occurred only in Montana and New Mexico where reserves rose 0.18 Tcf and 0.16 Tcf, respectively. Reserves in Texas dropped 6.4 Tcf, or 9.0%, and those in Louisiana declined 3.8 Tcf, or 6.2%.

Natural gas reserves committed to interstate pipelines declined during 1976 for the ninth consecutive year.

Dedicated domestic reserves dropped 8% in 1976, and domestic gas produced and purchased by interstate pipelines declined approximately 5% from the 1975 total of 12.0 Tcf to 11.4 Tcf in 1976. The reserve-production ratio for interstate reserves dropped from 8.9 at yearend 1975 to 8.6 by yearend 1976. Additional data are shown in the following tabulations:

Preliminary summary of domestic natural gas reserves, interstate natural gas pipeline companies

(Billion cubic feet at 14.73 psia and 60° F)

Total dedicated gas reserves as of December 31, 1975	r106,816
Revisions and additions during 1976	2,814
Gas reserves as of December 31, 1975 and changes during 1976	109,630
Gas produced during 1976	11,361
Total dedicated gas reserves as of December 31, 1976	98,269

rRevised.

Yearend domestic reserves, production and purchases of interstate natural gas pipeline companies

(Billion cubic feet at 14.73 psia and 60° F)

	Major supply companies	Minor supply companies	Total
Number of companies	26	32	58
Gas reserves at yearend:			
Company-owned	10,247	558	10,805
Independent producer contracts	86,111	1,353	87,464
Total	96,358	1,911	98,269
Percent of total	98.1	1.9	--
Annual production and purchases:			
Company-owned	616	52	668
Independent producer contracts	10,495	198	10,693
Total	11,111	250	11,361
Percent of total	97.8	2.2	--

STORAGE

The practice of storing natural gas, primarily near market areas, dates back to 1916. The purpose of this storage program is to help meet peak demand during the winter months when the capacities of long-distance transmission systems are inadequate and, hence, total demand cannot be met directly from producing areas. The total quantity of natural gas stored in underground reservoirs in the U.S. has expanded steadily since 1960, except during 1972 when inventories at yearend matched those of the preceding year, and in 1976 when colder than normal weather in the eastern two-thirds of the country resulted in a net drawdown of about 161 Bcf.

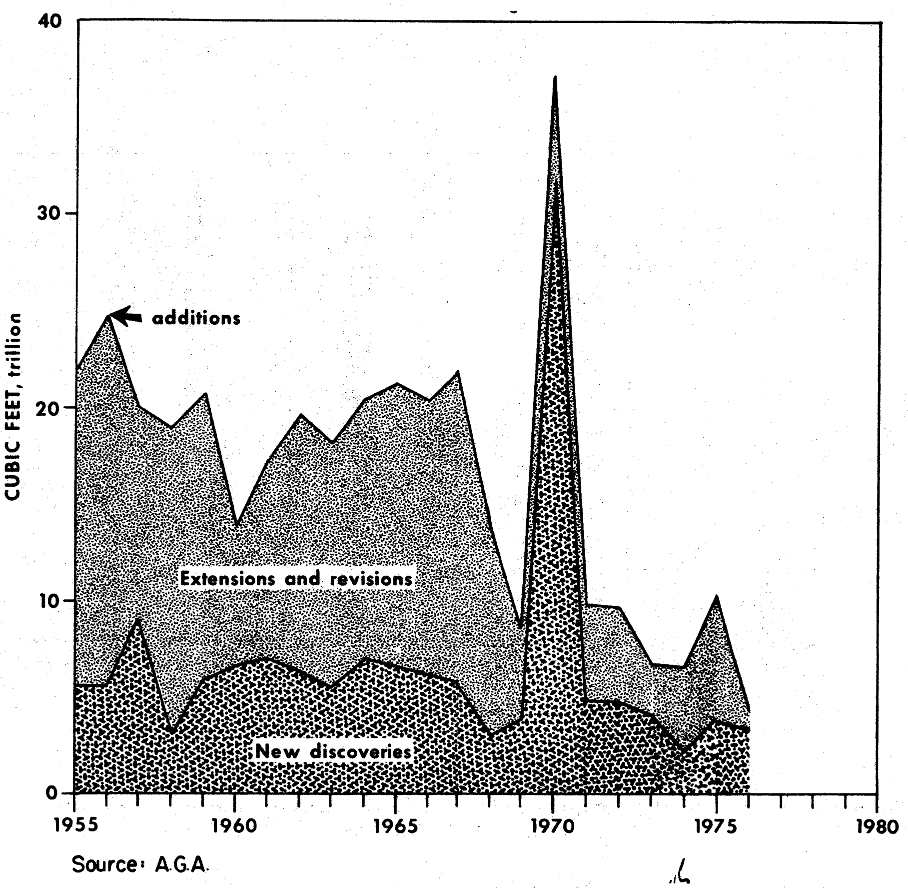

Figure 2.—Trends in annual additions to natural gas reserves.

By the end of 1976 there were 380 underground storage reservoirs with a capacity of 6,580 Bcf in use (table 17). An estimated four-fifths of the total were depleted oil and gas fields, and most of the remainder were of the aquifer type. A few salt caverns and an abandoned coal mine were also in use. Underground reservoirs were located mainly in the midwestern and northeastern U.S. where demand during the peak winter months is heaviest and markets are remote from their sources of supply. The greatest concentration of reservoirs was in Pennsylvania where 61 former oil and gas fields were in use. West Virginia and Michigan had 38 and 37 reservoirs in use, respectively, and Illinois followed closely with 34.

Total quantities of injected natural gas in underground storage at the beginning of 1976 were 4,400 Bcf (table 18). During the months of January, February, March, November, and December a total drawdown of 1,626 Bcf took place, while net injections during the remaining months totaled only 1,465 Bcf. The resultant net drawdown of 161 Bcf reduced yearend stock levels to 4,239 Bcf.

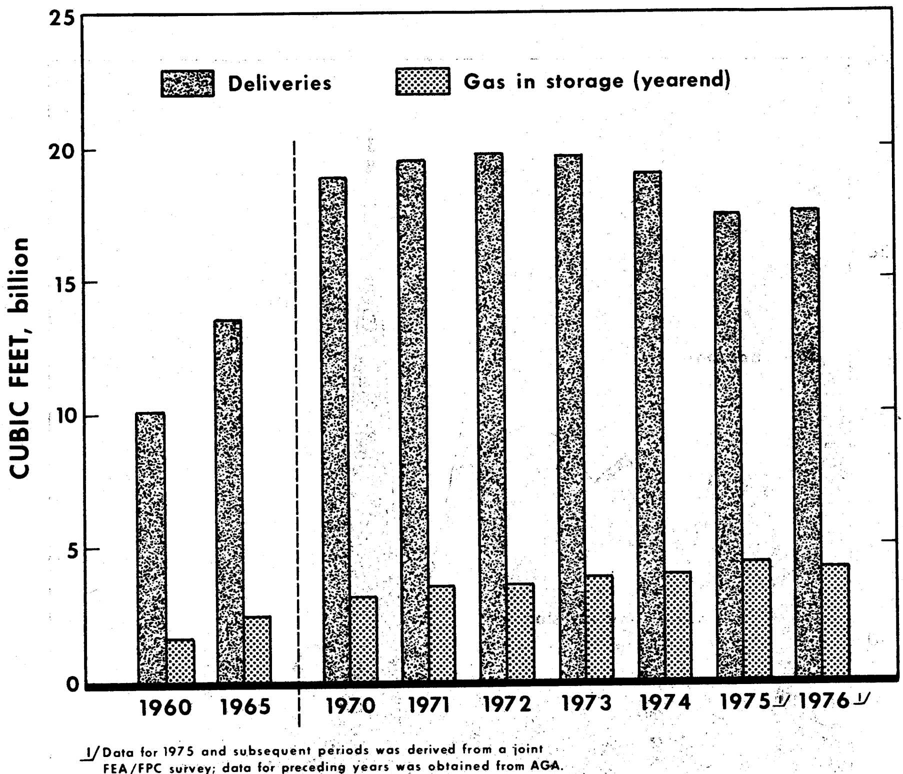

Figure 3.—Trends in total natural gas deliveries to consumers, and quantities of injected gas in underground storage (yearend).

In addition to supplies of natural gas in underground storage, smaller quantities are stored aboveground in liquefied form near markets or import terminals.

The following tabulation summarizes LNG storage data:

Facility	Status	Capacity (Bcf)	Number of plants
Peak shaving	Operational	53.7	54
Do	Under construction	5.2	6
Large satellite	Operational	6.3	22
Do	Under construction	1.5	1
Small satellite	Operational	0.2	31
Import-receiving terminals	Do	11.2	3
Do	Under construction	10.2	3
Total	Operational	71.4	110
Do	Under construction	16.9	10

In general, peakshaving facilities have both liquefaction and regasification capabilities while satellite facilities have only regasification equipment.

VALUE AND PRICE

Total wellhead value of marketed natural gas production increased 29.4% to $11,572 million in 1976, despite a 0.8% decline in production volume (table 19). This occurred as a result of a 30.3% increase in average wellhead value to 58 cents per Mcf. Texas and Louisiana accounted for 48.7% and 8.5%, respectively, of the $2,627 million increase in total value during 1976.

Wholesale prices.—Average wholesale prices for natural gas in the 14 large metropolitan areas for which FPC collects such data rose significantly between July 1, 1975 and July 1, 1976. Increases for individual metropolitan areas ranged from 7.5% to 52.2%, and the median price rise was 19.0%. Excluding the Los Angeles area average price of 82.09 cents per Mcf, which was actually the price at the California State line, the lowest wholesale price reported as of July 1, 1976 was 89.69 cents per Mcf in the Chicago area. The highest average price reported was 185.31 cents per Mcf in the Boston area.

A 7-year historical series of average wholesale natural gas prices in the 14 large metropolitan areas is shown in table 20. The wholesale prices for gas in those cities listed are based on the effective FPC gas tariffs. In cities served by more than one pipeline, prices are based on weighted average charges. Prices reflect deliveries at the city gate except for Los Angeles and San Francisco where distributors purchase gas at the California-Oregon and California-Arizona State lines.

Retail prices.—The average retail price for natural gas delivered to all classes of consumers increased 22.8% above 1975 levels to 146.5 cents per Mcf in 1976. The largest average increase was in the industrial sector where retail prices increased 28.6% to an average 124.0 cents per Mcf. Residential users paid an average 197.8 cents per Mcf in 1976 and the average price to commercial consumers was 169.3 cents per Mcf. Retail costs to electric utilities averaged 98 cents per Mcf.

Monthly data, collected by the Bureau of Labor Statistics on the average price of residential heating gas in 20 standard metropolitan areas, indicate an average increase of 19.4% in such costs between January 1976 and January 1977. Increases for individual areas ranged from 5.3% in Philadelphia to 43.9% in Cincinatti. The largest price increases occurred where prices have generally been lower, thus the disparity in prices between the 20 selected metropolitan areas narrowed significantly in 1976. A historical summary of average residential heating gas prices in 20 standard metropolitan statistical areas appears in table 21.

FOREIGN TRADE

Exports of natural gas totaled 64.7 Bcf in 1976, a decline of 11.0% from 1975. Of the total 1976 volume, 76.9% was shipped from Port Nikiski, Alaska to Japan as LNG. Exports via pipeline to Canada and Mexico were almost equally divided with Canada receiving 50.3% of the total deliveries.

The LNG exported to Japan in 1976 totaled 49.8 Bcf valued at $83 million compared with 53.0 Bcf valued at $73 million in 1975. Since no receiving terminals exist on the U.S. west coast and there were no U.S. flag LNG tankers capable of transporting LNG from Alaska to the east coast, all Alaskan LNG was exported. Federal Maritime law requires U.S. flag ships for all interstate seaborne trade. Statistics on LNG exports for 1976 are shown in table 22.

Exports via pipeline to Canada in 1976 totaled 7.5 Bcf compared with 10.2 Bcf in 1975, a decline of 26.6%. Detroit was the exit point for most of these shipments. Natural gas exports via pipeline to Mexico continued to decline from 9.5 Bcf in 1975 to 7.4 Bcf in 1976. Comparisons of exports in 1975 and 1976 are shown in table 23.

Pipeline imports of natural gas from Canada totaled 953.6 Bcf in 1976, an increase of 0.6%. These imports were valued at $1,652 million, compared with $1,147 in 1975. This large increase in value resulted from the continuing rapid increase in the average price of gas from 55.35 cents per Mcf in 1974 to 121.03 per Mcf in 1975 and 173.27 Mcf in 1976. Nine companies imported Canadian gas in 1976.

For the second consecutive year since 1955 there were no imports of natural gas from Mexico. Data on pipeline natural gas imports are shown in table 24.

Imports of LNG totaled 10.2 Bcf during 1976, more than double the 1975 total of 4.9

Bcf. These imports, shipped from Algeria to Everett, Mass., the U.S. receiving point, were valued at $7.9 million. There were no LNG imports from Canada in 1976. LNG import data are summarized in table 25.

The El Paso Algeria Corp.'s 25-year contract with Société Nationale pour la Recherche, la Production, le Transport, la Transformation et la Commercialisation des Hydrocarbures (SONATRACH), the Algerian National Oil and Gas Co., which has been approved by FPC, calls for the delivery of LNG equivalent to about 1 Bcf per day. This LNG will be transported from Algeria in a fleet of 9 tankers, owned and operated by El Paso. Each tanker will carry the equivalent of 2.6 Bcf of natural gas. Three of these ships, which were built in France, were completed as of the end of 1976, and the remaining six were in various stages of construction in U.S. shipyards. Deliveries to Cove Point, Md. and Elba Island, Ga. are expected to begin in 1978.

The receiving terminal at Cove Point, Md., which is jointly owned by Columbia LNG Corp. and Consolidated System LNG Co., will handle a quantity of LNG equivalent to 650 million cubic feet (MMcf) of gas per day when completed in 1977. Columbia will receive 300 MMcf and Consolidated 350 MMcf per day. After regasification of the LNG at Cove Point, the gas will be shipped by an 87-mile, 36-inch pipeline, completed in 1976, to a compressor station at Loudoun, Va., and then to transmission, distribution and storage facilities.

Construction of the receiving terminal on Elba Island near Savannah, Ga., owned by Southern Energy Co., was about 80% complete at yearend 1976 and is scheduled for completion in 1977. Southern will receive 350 MMcf of gas per day from El Paso.

Other proposed LNG projects were awaiting FPC approval. Among these, was that filed by Trunkline Gas Co. to import the equivalent of 168 Bcf of natural gas per year from Algeria, over a 20-year period, beginning in 1980. Trunkline requested approval to construct a receiving terminal with storage and regasification facilities near Lake Charles, La., at an estimated cost of $164.3 million.

Another project awaiting approval was that of Tenneco Corp. to import LNG from Algeria to the U.S. via Canada. This 20-year contract calls for the delivery of the equivalent of 397 Bcf of natural gas per year to St. Johns, New Brunswick, Canada. After regasification, 280 Bcf of gas per year would enter the U.S. by pipeline and the remainder would be used in Canada. This would involve the construction of a pipeline, at an estimated cost of $546.4 million, consisting of about 391 miles of 30-inch line from the Maine-New Brunswick border to Albany, N.Y. and 107 miles of 30-inch line extending from there to Tennessee Gas Pipeline Co.'s main transmission line near Milford, Pa.

An application was filed with FPC by Pacific Indonesia LNG Co. to import LNG equivalent to about 539 MMcf of gas per day from Indonesia for a 20-year period. Western LNG Terminal Co. requested approval to construct and operate an LNG receiving terminal near Oxnard, Calif. to handle these imports.

El Paso Eastern Co. requested approval to import LNG from Algeria to a terminal in Matagorda Bay on the Texas Gulf Coast. This 20-year contract with SONATRACH calls for the delivery of 1 Bcf per day of LNG, scheduled to begin in 1984. The LNG would be shipped by a fleet of 12 cryogenic tankers, with El Paso Atlantic Co. providing 6 of the ships and the remaining 6 to be provided by SONATRACH. After regasification of the LNG, 65% would be sold to El Paso Natural Gas Co. and 35% to United Gas Pipe Line Co. El Paso would construct a terminal and 463 miles of pipeline to existing pipeline systems at an estimated total cost of $720 million. The proposed pipeline would connect with El Paso's Waha gas plant in Reeves County, Tex., and would intersect with United's existing line near Victoria, Tex.

WORLD REVIEW

World marketed production of natural gas totaled 49.4 Tcf in 1976 (table 26), an increase of 1.9 Tcf or 3.96% from that in 1975. The United States was the largest producer, accounting for 40.4% of the total.

Algeria.—SONATRACH expanded its natural gas production and processing facilities, and marketed production during the year increased 10% to 370.8 Bcf. Almost all marketed natural gas production was exported as LNG.

Early in 1976, SONATRACH issued a contract valued at $480 million to the C. Itoh Commercial Group and Japan Gasoline

Co., Ltd., to install gas processing units at Hassi R'Mel gasfield rated at 3,860 MMcf per day that will have the capacity to produce 300,000 barrels per day (bpd) of condensate and 95,000 bpd of liquefied petroleum gas (LPG).

Construction of SONATRACH's Arzew No. 1 gas liquefaction plant continued during 1976. Deliveries of LNG from this plant for export to the United States were expected to commence early in 1978.

During 1976 SONATRACH finalized plans to construct two LNG plants at Bettioua, near Arzew on Algeria's western coast. Both facilities were scheduled to begin operations in 1979. One of the plants, to be built by Foster Wheeler Corp., will have the capacity to liquefy up to 1.5 Bcf of gas per day for export. The Algerians contracted Pullman Inc. to design and build the other plant at Bettioua with six liquefaction units, each with a capacity to liquefy in excess of 150 MMcf of gas per day for export to Europe and the United States.

Société d'Etudes du Gazoduc de la Mediterranee Occidentale (SEGAMO), an organization owned by Algeria, France, and Spain, examined possible routes for a long-distance, natural gas pipeline to deliver Algerian gas across the Mediterranean Sea to Europe and contracted Williams Companies to prepare a study of the seafloor between Algeria and Spain. The projected 1,550-mile gasoline crossing the Mediterranean Sea between Algeria and Italy and passing through Tunisia was reportedly cancelled at yearend 1976, when Tunisia rejected its permission to build the trunk line across its territory.

Canada.—Marketed production of natural gas in Canada which ranked fourth in total world output, totaled 3.067 Tcf in 1976, a decrease of 0.7% from that of 1975. Most of this production was from the Province of Alberta, although significant quantities were also produced in British Columbia. Exports of natural gas to the United States totaled 954 Bcf in 1976, up 0.6% from 1975.

The Canadian Petroleum Association estimated natural gas reserves at 58.3 Tcf as of yearend 1976, an increase of 1.3 Tcf from yearend 1975. Exploratory drilling for natural gas continued at a high level in western Canada, but continued to decline in the Arctic region during 1976. The decrease in Arctic activity was due in part to the uncertainty of Government energy policies and extremely high operating costs.

Petro-Canada Ltd., the newly-formed national oil and gas entity, signed joint venture agreements with several companies to explore for natural gas off Canada's east coast. The joint ventures included an $18 million project with Shell Canada Ltd. and Shell Explorer Ltd. to drill four wells; a $3 million project with Mobil Oil Canada Ltd. to drill a well near Banquereau Bank; and a $3 million project with Francana Oil and Gas Ltd., Murphy Oil Co., Ltd., and Soquip, the Quebec Governmental oil and gas concern, to drill a well offshore Sydney, Nova Scotia.

Other offshore exploration programs included that initiated by Dome Petroleum Ltd. to drill several wells in the Beaufort Sea offshore the Mackenzie Delta. Eastcan Exploration Ltd. planned to use drillships and a semisubmersible rig to explore for natural gas on the Labrador Shelf.

Gulf Oil Canada Ltd. and Mobil Oil Canada Ltd. tested a development well in the Parsons Lake Field, Mackenzie Delta, at up to 20.5 MMcf per day, and Eastcan Exploration Ltd. tested a discovery well on the Labrador Shelf some 700 miles north of St. Johns, Newfoundland, at 9.8 MMcf per day. Other significant new gas wells tested during 1976 included: Husky Oil Ltd., near Chatham, Ontario, 16.5 MMcf per day; Panarctic Oils Ltd., two discoveries off Melville Island in the Arctic Islands, one at 6.5 and the other at 6.8 MMcf per day; and Shell Canada Ltd., 90 miles northwest of Calgary, Alberta, up to 12.7 MMcf per day.

Several natural gas pipeline projects were completed or in the planning stage during 1976. Alberta Gas Trunk Line, Ltd. completed over 500 miles of various-diameter lines and announced plans to construct 134 miles of large-diameter lines. TransCanada Pipe Lines Ltd. planned the addition of about 70 miles of loop lines to its gas pipelines system in Central Canada. Alberta Oil Sands Pipeline Ltd. planned to build a 170 mile, 16-inch pipeline to transport gas to the Syncrude Ltd. tar sands extraction plant, and West Coast Transmission Co. approved a 4-year program to lay over 440 miles of natural gas gathering lines in western Canada. An 87-mile pipeline is to be constructed in British Columbia from the Grizzly gasfield to a proposed sulfur-scrubbing plant near Chetwynd.

Competing projects were under consideration to move natural gas by pipeline from northern producing areas to markets in the southern Provinces. Two proposals called for the construction of large-diameter international gas pipeline's through Canada from the Alaskan border to existing pipelines in Alberta and British Columbia. Either of these trunklines would be used to deliver Alaskan gas to consumers in the lower 48 States and eventually, to move gas from Canada's Mackenzie Delta to markets in the lower Provinces.

Another plan under consideration called for the construction of a domestic gas line, costing about $3 billion, from the Mackenzie Delta to existing facilities in Alberta.

Indonesia.—Expanded production and processing facilities resulted in Indonesia's total marketed production of natural gas increasing by nearly 54% to 126.4 Bcf in 1976, three times greater than the country's output 2 years earlier. Atlantic Richfield Co. completed the construction of an offshore natural gas processing plant in the Ardjuna Field, in the Java Sea near Jakarta, Java, that will produce up to 20,000 bpd of liquefied petroleum gas and supply the residue gas to onshore industries at the rate of about 200 MMcf per day. A 150-mile gas pipeline was being laid from the plant to a steel mill at Cilegon and to a fertilizer plant at Ceribon.

Two LNG plants and export terminals were under construction by Pertamina, the Government-owned oil and gas entity, one at Badak Field near Balikpapan, Kalimantan, and the other at Aceh Field, North Sumatra. Shipments of Indonesian LNG will be made from these facilities to Japan and possibly, the United States. The Kalimantan plant, which was scheduled to begin operations in 1977, will be capable of processing about 5,700 bpd of natural gas liquids from associated gas and will have the capacity to liquefy about 550 MMcf of natural gas per day. The Sumatra plant, which will be capable of liquefying about 1 Bcf of natural gas per day, was scheduled for completion in 1978.

Mexico.—Marketed production of natural gas by the Government-owned oil and natural gas entity, Petróleos Mexicanos, S.A. (Pemex) totaled 577.9 Bcf in 1976, a decrease of 1% from that in 1975. Large quantities of the gas produced contained hydrogen sulfide and required treatment prior to delivery to the market. Half of the gas was produced in association with the production of crude oil, and the remainder was nonassociated natural gas. Nearly 70% of the output came from fields in southern Mexico, 22% from northern fields, and 8% from fields in the Poza Rica area near the Gulf of Mexico midway between the two major producing areas.

Extensive facilities were being developed in the States of Chiapas and Tabasco in southern Mexico to process large quantities of sour gas from the recently discovered Reforma fields. Units rated at a total capacity of 600 MMcf per day were under construction or operating at Cactus in 1976, and more units will be added during 1977 to increase the capacity there to 1 Bcf per day.

Production from the promising Reforma fields was expected to raise Mexico's total gas output considerably within the next few years, and significant volumes may become available for export, possibly to the United States.

Netherlands.—Natural gas reserves fell by 3% to 83.9 Tcf at yearend 1976, the first decline since the discovery of the prolific Groningen Field in 1959. Total reserves included offshore North Sea fields 13.2 Tcf, Groningen 62 Tcf, and other onshore fields 8.7 Tcf. Marketed production of natural gas in the Netherlands increased by 7.1% to a record 3.4 Tcf during 1976, and the country maintained its position as the world's third largest producer of natural gas.

Norway.—As of yearend 1976, numerous projects were underway or completed in Norway's sector of the North Sea to transport natural gas to markets on the European continent. Deliveries of natural gas from the offshore Ekofisk Field to Emder, West Germany, via a 274-mile pipeline completed in 1976, were scheduled to begin in 1977. Natural gas will be piped from the Emden terminal to consumers in Belgium, France, Netherlands, and West Germany.

Norway and the United Kingdom signed an agreement for the joint development of the Frigg gasfield in the North Sea, and the Norwegian Government initiated a study on the feasibility of gas pipeline construction from offshore fields to markets in Norway.

United Kingdom.—Developments in the North Sea dominated the natural gas industry in the United Kingdom during 1976, and the country maintained its position as the third largest producer of marketed natural gas in Europe. Eleven gas compressing and processing units were under construction at Brent Field to compress gas initially for reinjection and later to process the gas to be piped to shore installations. A $40 million, 200,000 ton, concrete gas treatment platform was installed at Frigg Field, and construction teams laid twin 31-inch, 217-mile gas pipelines from the field to St. Fergus, Scotland. A new gas well in the Morecambe Field of the Irish Sea tested 10-15 MMcf per day.

Gas discoveries in the North Sea during

1976 included a well near Brae Field, which tested 12 MMcf per day, one near Beryl Field, which tested 23.7 MMcf per day, and one near Bacton, England, which tested 18 MMcf per day.

At yearend 1976, the Government was studying a proposal to construct approximately 840 miles of gas gathering lines from producing fields in the North Sea to Peterhead, Scotland.

U.S.S.R.—The U.S.S.R. was second to the United States accounting for 23% of world production. Its 1976 marketed production of natural gas reached a record 11.3 Tcf, up 11% from 1975 and more than 50% above that produced 5 years earlier. Most of the Soviet output came from the Ukraine, Turkmenistan and western Siberia.

Construction was completed during 1976 at the Orenburg gas processing complex, one of the largest in the world. Approximately 1.9 Bcf per day of gas from nearby fields will be processed for the removal of natural gas liquids and sulfur, and then piped to consumers in the U.S.S.R. and other European countries.

Plans were finalized for the development of the Golitsyna gasfield in the Black Sea, about 43 miles west of the Tarkhankut. A confirmation well completed in 1976 flowed 35.3 MMcf per day.

Several thousand miles of natural gas pipelines were built during 1976, with more than 4,000 miles of lines scheduled to be constructed in 1977. Construction was completed during 1976 on nearly half of the 1,680-mile, large-diameter, natural gas trunk lines from the Orenburg Field near the Caspian Sea to Uzhgorod, on the border with Czechoslovakia. Scheduled for completion during 1978, the line will have a design capacity to transport 2.7 Bcf per day of natural gas to several European countries.

The looping of a 600-mile section of the gas pipeline from the giant Vuktyloskoye gasfield, north of Ukhta and near the Arctic Circle, to Torzhok, in European Russia between Leningrade and Moscow at Torzhok was completed in 1976. The line connects with international gas lines serving Czechoslovakia and Poland.

At yearend 1976, a major natural gas trunk line was under construction in western Siberia from the huge Urengoiskoye Field to Nadym. Projects remained in the planning stage to construct long-distance gas pipelines to Japan from Sakhalin Island and from near Yakutsk, in eastern Siberia.

TECHNOLOGY

Government and industry activities in the development of technology designed to increase gas supplies continued in 1976. These efforts involved several techniques to produce gaseous fuel from coal, the gasification of petroleum liquids, the recovery of gas from low permeability formations and methane saturated aquifers, and the production of gas from biomass.

Research involving the gasification of mined coal to produce high-Btu gas was expanded during 1976 as the total number of pilot plants in operation was increased to seven by the completion of four new facilities. In addition, two pilot projects involving the production of low-Btu gas from coal were operational, one was being modified, another was under construction, and two were in the design stage as of yearend 1976. The Energy Research and Development Administration (ERDA) initiated negotiations during the year with private firms for the design of high-Btu and low-Btu coal gasification demonstration projects, and private interests filed applications with the FPC for the construction of two commercial high-Btu plants.

Research involving the production of low-Btu gas by in situ gasification of coal seams was in progress. During 1976, the Laramie Energy Research Center conducted experiments near Hanna, Wyo., which produced low-Btu gas of uniform quality over sustained periods. A consortium of three Texas electric utilities, Texas Utilities Services, Inc., initiated tests involving the in situ gasification of lignite using technology developed in the Soviet Union.

A Bureau of Mines demonstration project continued to gather methane from an operating coal mine near Bula, W. Va. Deliveries of small quantities of methane from this project to Consolidated Gas Supply Corp. occurred during 1976. The Bureau also signed a contract with Emerald Mine Corp. involving a pre-production methane gathering project at a coal mine in Green County, Pa. The goal of both these projects was the development of techniques which would provide additional natural gas supplies for distribution, and also reduce coal-mining hazards.

SNG plants, using naphtha and natural gas liquids as feedstocks, continued to provide supplemental gas supplies, primarily during the winter months. As of yearend 1976, 12 SNG plants were in operation and 1 was under construction.

Research has also focused on fracturing techniques that stimulate flow from economically submarginal gas reservoirs. During 1976, a total of nine fracturing projects were in progress in Wyoming, Colorado, Utah, and Texas, and five projects were underway in the Appalachian area. Several of the latter projects involved fracturing of the Upper Devonian gas shales which underlie about 12 eastern States, including those that comprise the major northeastern markets.

During 1976, a Government-industry contract was signed for the investigation of methane-saturated Gulf coast salt water aquifers. A previous study by the U.S. Geological Survey indicated that these aquifers in onshore reservoirs alone may contain up to 24,000 Tcf of methane.

A program to encourage the development of techniques from the conversion of renewable biomass resources into methane by biochemical, thermochemical, and photochemical processes was initiated by ERDA in 1976. Several resource inventory and technology assessment contracts were awarded universities and other private research organizations. In addition, a contract was awarded for the construction of a pilot plant to test the technical and economic feasibility of converting garbage to methane using anaerobic digesters.

Table 2.—Gas pipeline failures reported during 1975-76

System and cause of failure	Total number of failures		Fatalities				Injuries			
			Employees		Non-employees		Employees		Non-employees	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Distribution:										
Corrosion	94	118	--	--	1	1	6	8	23	33
Damage by outside forces	744	659	--	2	5	16	7	16	119	103
Construction defect or material failure	78	115	--	--	--	27	1	20	25	81
Other causes	63	144	--	1	2	6	15	22	24	36
Total	979	1,036	--	3	8	50	29	66	191	253
Transmission and gathering:										
Corrosion	44	115	3	--	1	--	2	--	4	--
Damage by outside forces	237	219	--	--	--	8	--	--	5	5
Construction defect or material failure	88	180	1	1	--	--	5	6	--	2
Other causes	25	29	1	1	--	--	1	22	--	12
Total	394	543	5	2	1	8	8	28	9	19
Grand total	1,373	1,579	5	5	9	58	37	94	200	272

Source: Office of Pipeline Safety, Department of Transportation.

Table 3.—Gross withdrawals and disposition of natural gas in the United States

(Million cubic feet at 14.73 psia)

State	Gross withdrawals			Disposition		
	From gas wells	From oil wells	Total[1]	Marketed production	Repressuring	Vented and flared[2]
1975						
Alabama	33,660	5,261	38,921	37,814	--	1,107
Alaska	138,153	115,074	253,227	160,270	82,556	10,401
Arizona	4	251	255	208	--	47
Arkansas	91,270	30,248	121,518	116,237	3,963	1,318
California	173,499	194,154	367,653	318,308	47,808	1,537
Colorado	130,743	43,402	174,145	171,629	--	2,516
Florida	--	44,383	44,383	44,383	--	--
Illinois	1,440	(3)	1,440	1,440	--	--
Indiana	346	(3)	346	346	--	--
Kansas	705,746	140,418	846,164	843,625	1,693	846
Kentucky	60,511	(3)	60,511	60,511	--	
Louisiana	6,455,690	786,718	7,242,408	7,090,645	126,304	25,459
Maryland	93	--	93	93	--	--
Michigan	71,907	31,994	103,901	102,113	176	1,612
Mississippi	74,367	18,133	92,500	74,345	6,293	11,862
Missouri	30	(3)	30	30	--	--
Montana	41,474	3,073	44,547	40,734	611	3,202
Nebraska	1,605	2,358	3,963	2,565	--	1,398
New Mexico	915,370	311,830	1,227,200	1,217,430	8,128	1,642
New York	7,628	(3)	7,628	7,628	--	--
North Dakota	287	26,654	26,941	24,786	--	2,155
Ohio	85,810	(3)	85,810	84,960	850	--
Oklahoma	1,412,637	308,061	1,720,698	1,605,410	83,486	31,802
Pennsylvania	84,772	(3)	84,772	84,676	--	96
South Dakota	39	(3)	39	--	35	4
Tennessee	27	585	612	27	--	585
Texas	6,463,095	1,525,678	7,988,773	7,485,764	471,714	31,295
Utah	19,001	58,606	77,607	55,354	20,447	1,806
Virginia	6,723	--	6,723	6,723	--	--
West Virginia	154,484	(3)	154,484	154,484	--	--
Wyoming	249,882	76,356	326,238	316,123	6,892	3,223
Total	17,380,293	3,723,237	21,103,530	20,108,661	860,956	133,913
1976						
Alabama	37,832	5,768	43,600	41,427	1,085	1,088
Alaska	142,944	126,167	269,111	166,072	96,485	6,554
Arizona	3	291	294	262	--	32
Arkansas	91,166	29,981	121,147	109,533	10,387	1,227
California	174,477	253,163	427,640	354,334	72,018	1,288
Colorado	134,110	51,918	186,028	183,972	220	1,836
Florida	--	46,513	46,513	43,165	2,511	837
Illinois	1,556	(3)	1,556	1,556	--	--
Indiana	192	(3)	192	192	--	--
Kansas	704,197	127,467	831,664	829,170	1,663	831
Kentucky	66,137	(3)	66,137	66,137	--	--
Louisiana	6,365,774	777,266	7,143,040	7,006,596	104,977	31,467
Maryland	75	--	75	75	--	--
Michigan	81,628	40,003	121,631	119,262	327	2,042
Mississippi	73,138	16,776	89,914	70,762	5,553	13,599
Missouri	29	(3)	29	29	--	--
Montana	41,685	3,412	45,097	42,563	464	2,070
Nebraska	899	2,409	3,308	2,511	--	797
New Mexico	939,491	300,161	1,239,652	1,230,976	7,157	1,519
New York	9,235	(3)	9,235	9,235	--	--
North Dakota	285	33,922	34,207	31,470	--	2,737
Ohio	89,780	(3)	89,780	88,891	889	--
Oklahoma	1,491,165	351,024	1,842,189	1,726,513	85,479	30,197
Pennsylvania	89,485	(3)	89,485	89,386	--	99
South Dakota	52	(3)	52	--	47	5
Tennessee	47	485	532	47	146	339
Texas	6,213,395	1,452,537	7,665,932	7,191,859	443,671	30,402
Utah	18,927	59,719	78,646	57,416	20,182	1,048
Virginia	6,937	--	6,937	6,937	--	--
West Virginia	153,322	(3)	153,322	153,322	--	--
Wyoming	262,692	74,141	336,833	328,768	6,149	1,916
Total	17,190,655	3,753,123	20,943,778	19,952,438	859,410	131,930

[1]Marketed production plus quantities used in repressuring and vented and flared.
[2]Partly estimated; includes direct losses on producing properties and residue blown to the air.
[3]Not reported separately, included under "Gross withdrawals from gas wells."
Source: Figures based on reports from State agencies.

Table 4.—Gas and oil well completions in the United States, by State, 1971-76

State	Gas completions[1]						Oil completions[2]					
	1971	1972	1973	1974	1975	1976	1971	1972	1973	1974	1975	1976
Alabama	6	9	10	16	26	36	8	13	18	16	20	29
Alaska	1	2	3	4	4	1	27	12	20	27	44	50
Arizona	2	1	1	--	--	--	--	5	--	3	--	--
Arkansas	29	39	40	41	23	45	127	96	91	99	147	217
California	60	62	65	69	46	76	1,459	1,045	879	1,567	1,854	1,833
Colorado	148	124	148	201	300	178	154	300	228	218	328	415
Florida	--	--	--	--	--	--	8	65	24	9	15	11
Illinois	16	18	13	11	5	12	252	255	240	357	460	759
Indiana	2	5	8	21	17	23	81	92	67	136	145	191
Kansas	112	368	384	389	438	540	1,099	880	592	989	1,094	1,473
Kentucky	135	166	157	127	123	151	244	230	158	195	304	381
Louisiana:												
North	237	451	269	458	413	808	390	291	234	326	402	454
South	200	234	284	190	220	211	398	375	337	283	373	294
Offshore	184	133	231	141	182	239	258	253	287	216	181	200
Total Louisiana	621	818	784	789	815	1,258	1,046	919	858	825	956	948
Maryland	--	--	--	--	--	2	--	--	--	--	--	--
Michigan	33	34	41	52	33	64	81	87	73	116	169	118
Mississippi	13	13	28	26	31	44	175	87	70	67	83	108
Missouri	1	--	--	2	1	7	6	--	--	7	6	6
Montana	33	125	123	145	279	190	45	83	46	60	100	91
Nebraska	1	2	--	5	1	2	47	48	33	40	74	87
New Mexico	186	238	498	463	517	350	401	502	280	350	437	402
New York	7	22	27	98	236	355	83	96	97	153	142	133
North Dakota	1	--	--	--	--	--	49	23	40	42	69	93
Ohio	608	721	940	1,050	555	1,121	391	426	393	567	550	640
Oklahoma	238	341	539	744	638	790	1,174	1,025	898	1,149	1,743	1,991
Pennsylvania	199	297	434	468	640	565	394	534	525	671	691	651
South Dakota	--	--	--	--	--	--	2	4	5	1	5	4
Tennessee	23	9	10	12	38	38	57	14	24	61	46	47
Texas	810	943	1,475	1,843	2,135	2,443	3,880	3,963	3,686	4,402	6,074	5,779
Utah	6	13	25	12	19	8	30	73	104	118	110	62
Virginia	--	18	7	55	26	7	--	--	--	--	2	--
West Virginia	496	488	514	556	556	699	133	84	72	121	120	124
Wyoming	43	52	61	40	78	80	405	345	381	418	620	416
Grand total	3,830	4,928	6,335	7,239	7,580	9,085	11,858	11,306	9,902	12,784	16,408	17,059

[1]Includes multiple completion wells that produce gas from all zones.
[2]Includes multiple completion wells that produce gas from one or more zones but oil from at least one zone.

Source: American Petroleum Institute. Quarterly Review of Drilling Statistics for the United States, Annual Summaries 1971 to 1976, inclusive.

Table 5.—Exploratory wells drilled in the United States, by State, 1971-76

State	Gas completions[1]						Oil completions[2]					
	1971	1972	1973	1974	1975	1976	1971	1972	1973	1974	1975	1976
Alabama	2	6	5	4	8	15	3	2	4	5	4	5
Alaska	--	1	1	3	3	--	1	--	2	2	6	--
Arizona	1	1	1	--	--	--	--	--	--	--	--	--
Arkansas	2	1	2	2	1	1	9	7	4	8	9	9
California	5	9	17	16	17	18	21	17	17	28	36	29
Colorado	27	29	29	26	19	33	29	71	38	25	37	28
Florida	--	--	--	--	--	--	--	2	3	2	--	--
Illinois	4	2	1	3	--	--	24	20	22	25	29	40
Indiana	1	3	3	6	5	8	14	11	11	18	15	25
Kansas	14	26	40	33	37	46	131	117	98	98	115	132
Kentucky	12	18	16	20	21	37	23	30	18	24	58	54
Louisiana	72	79	54	61	82	71	43	24	22	24	30	28
Michigan	13	21	31	34	17	36	26	34	38	50	55	29
Mississippi	3	4	15	6	5	14	13	9	13	23	23	29
Missouri	--	--	--	1	1	1	--	--	--	--	--	--
Montana	16	29	28	35	44	36	4	15	10	10	14	22
Nebraska	--	--	--	3	1	2	7	10	7	13	17	27
New Mexico	7	27	25	48	36	37	6	14	9	8	26	17
New York	3	3	3	19	9	20	--	1	2	--	1	--
North Dakota	--	--	--	--	--	--	8	7	4	11	14	20
Ohio	7	24	31	117	87	118	--	2	--	20	10	22
Oklahoma	27	55	69	61	52	65	42	37	35	51	59	70
Pennsylvania	3	20	41	42	46	30	1	3	3	11	11	10
South Dakota	--	--	--	--	--	--	2	--	4	--	4	--
Tennessee	14	7	8	11	30	34	16	4	6	17	13	17
Texas	172	183	410	562	571	692	186	179	207	278	311	386
Utah	4	2	13	4	6	3	8	22	4	4	7	2
Virginia	--	--	2	5	2	--	--	--	--	--	2	--
West Virginia	18	35	39	53	42	63	1	1	4	5	3	5
Wyoming	10	16	16	19	29	22	33	45	34	54	63	41
Total	437	601	900	1,194	1,171	1,402	651	684	619	814	972	1,047

[1]Includes multiple completion wells that produce gas from all zones.
[2]Includes multiple completion wells that produce gas from one or more zones but oil from at least one zone.

Source: American Petroleum Institute. Quarterly Review of Drilling Statistics for the United States, Annual Summaries 1971 to 1976, inclusive.

Table 6.—Producing gas and condensate wells in the United States[1]

PAD district and State	Dec. 31, 1972	Dec. 31, 1973	Dec. 31, 1974	Dec. 31, 1975	Dec. 31, 1976
District 1:					
Maryland	16	15	15	15	14
New York	650	789	700	900	1,400
Pennsylvania	16,600	16,600	17,123	r17,300	17,500
Virginia	130	178	174	186	180
West Virginia	21,324	21,400	21,450	21,700	22,100
Total	38,720	38,982	39,462	r40,101	41,194
District 2:					
Illinois	31	36	37	41	34
Indiana	87	106	474	478	563
Kansas	8,621	8,785	8,800	8,865	9,330
Kentucky	7,099	7,224	7,307	7,386	7,505
Michigan	1,317	1,145	503	209	214
Missouri	3	2	3	3	3
Nebraska	29	29	25	19	17
North Dakota	21	44	34	18	34
Ohio	8,630	9,406	10,038	10,382	11,509
Oklahoma	8,457	8,868	9,401	9,769	10,436
South Dakota	5	10	20	20	20
Tennessee	45	6	13	5	7
Total	34,345	35,661	36,655	37,195	39,672
District 3:					
Alabama	15	15	r34	r45	66
Arkansas	1,041	876	1,172	1,128	1,223
Louisiana	9,456	10,551	r11,148	r11,359	11,370
Mississippi	252	250	239	248	257
New Mexico	9,679	9,711	9,915	10,352	10,674
Texas	23,373	23,805	24,646	26,184	27,762
Total	43,816	45,208	r47,154	r49,316	51,352
District 4:					
Colorado	934	1,050	r1,039	r1,380	1,500
Montana	1,116	1,118	1,450	1,235	1,490
Utah	200	158	114	271	71
Wyoming	887	850	900	950	990
Total	3,137	3,176	r3,503	r3,836	4,051
District 5:					
Alaska	50	52	52	61	50
Arizona	4	4	1	1	1
California	1,086	1,095	1,142	1,585	1,123
Total	1,140	1,151	1,195	1,647	1,174
Total United States	121,158	124,178	r127,969	r132,095	137,443

rRevised.
[1]Based on State reports, State estimates, and World Oil magazine.

Table 7.—Consumption of natural gas, by use and by State, in 1976

Region and State	Delivered to consumers: Quantity (million cubic feet)	Delivered to consumers: Value (thousand dollars)	Extraction loss: Quantity (million cubic feet)	Extraction loss: Value (thousand dollars)	Lease and plant fuel: Quantity (million cubic feet)	Lease and plant fuel: Value (thousand dollars)	Pipeline fuel: Quantity (million cubic feet)	Pipeline fuel: Value (thousand dollars)	Total: Quantity (million cubic feet)	Total: Value (thousand dollars)
New England:										
Connecticut	65,828	208,519	--	--	--	--	27	16	65,855	208,535
Maine, New Hampshire, Vermont	13,545	34,644	--	--	--	--	--	--	13,545	34,644
Massachusetts	155,619	517,609	--	--	--	--	628	388	156,247	517,997
Rhode Island	20,685	63,193	--	--	--	--	12	9	20,697	63,202
Total	255,677	823,965	--	--	--	--	667	413	256,344	824,378
Middle Atlantic:										
New Jersey	321,033	887,142	--	--	--	--	502	205	321,535	887,347
New York	592,679	1,482,990	--	--	273	233	2,981	1,615	595,933	1,484,838
Pennsylvania	688,901	1,206,173	61	62	3,043	2,288	21,574	12,927	713,579	1,221,450
Total	1,602,613	3,576,305	61	62	3,316	2,521	25,057	14,747	1,631,047	3,593,635
East North Central:										
Illinois	1,158,567	1,960,084	12,477	6,147	110	51	16,558	9,653	1,187,712	1,975,935
Indiana	420,175	576,158	--	--	--	--	5,046	2,283	425,221	578,441
Michigan	868,592	1,511,973	6,665	5,848	7,647	6,468	11,796	8,399	894,700	1,532,688
Ohio	995,460	1,596,175	--	--	2,742	2,710	7,725	4,090	1,005,927	1,602,975
Wisconsin	312,845	540,098	--	--	--	--	2,309	1,246	315,154	541,344
Total	3,755,639	6,184,488	19,142	11,995	10,499	9,229	43,434	25,671	3,828,714	6,231,383
West North Central:										
Iowa	302,557	375,762	--	--	--	--	8,868	4,626	311,425	380,388
Kansas	421,122	419,848	40,975	29,428	31,044	20,978	63,031	25,613	556,172	495,867
Minnesota	316,243	438,639	--	--	--	--	3,913	2,363	320,156	441,002
Missouri	375,005	514,860	--	--	--	--	5,253	2,502	380,258	517,362
Nebraska	187,520	201,214	259	179	708	296	10,406	4,352	198,893	206,041
North Dakota	25,100	38,342	2,421	1,404	15,998	6,335	79	45	43,598	46,126
South Dakota	39,176	46,133	--	--	--	--	31	17	39,207	46,150
Total	1,666,723	2,034,798	43,655	31,011	47,750	27,609	91,581	39,518	1,849,709	2,132,936

Table 7.—Consumption of natural gas, by use and by State, in 1976 —Continued

Region and State	Delivered to consumers		Extraction loss		Lease and plant fuel		Pipeline fuel		Total	
	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)
South Atlantic:										
Delaware	19,182	38,720	--	--	--	--	--	--	19,182	38,720
Florida	280,844	304,133	13,865	8,721	6,306	4,357	1,867	917	302,882	318,128
Georgia	257,866	348,130	--	--	--	--	3,454	1,228	261,320	349,358
Maryland and District of Columbia	173,590	387,327	--	--	415	448	2,267	1,135	176,272	388,910
North Carolina	98,391	187,933	--	--	--	--	2,784	1,284	101,175	189,217
South Carolina	145,587	226,673	--	--	--	--	3,402	1,776	148,989	228,449
Virginia	120,647	247,464	--	--	157	132	2,705	1,447	123,509	249,043
West Virginia	135,378	198,629	8,284	5,318	1,490	898	13,855	9,603	159,007	214,448
Total	1,231,485	1,939,009	22,149	14,039	8,368	5,835	30,334	17,390	1,292,336	1,976,273
East South Central:										
Alabama	215,071	304,538	661	467	2,714	1,943	8,194	3,818	226,640	310,766
Kentucky	224,329	269,187	5,231	3,102	1,040	371	20,598	9,916	251,198	282,576
Mississippi	163,763	193,352	520	243	4,836	2,427	30,523	13,893	199,642	209,915
Tennessee	196,695	259,836	--	--	537	355	15,094	7,322	212,326	267,513
Total	799,858	1,026,913	6,412	3,812	9,127	5,096	74,409	34,949	889,806	1,070,770
West South Central:										
Arkansas	235,440	218,114	823	407	4,049	1,681	9,452	4,928	249,764	225,130
Louisiana	1,406,467	1,351,935	172,584	156,016	556,772	298,430	80,466	39,998	2,216,289	1,846,379
Oklahoma	648,957	626,713	52,087	38,805	84,025	35,408	27,128	9,847	812,197	710,773
Texas	3,173,401	3,872,806	428,635	478,785	729,946	449,647	71,960	36,772	4,403,942	4,838,810
Total	5,464,265	6,069,568	654,129	674,013	1,374,792	785,166	189,006	91,545	7,682,192	7,620,292
Mountain:										
Arizona	155,904	208,798	--	--	--	--	15,371	6,735	171,275	215,533
Colorado	287,904	302,437	11,944	10,642	7,739	5,038	6,641	4,763	314,228	322,880
Idaho	42,527	78,842	--	--	5	5	4,624	3,343	47,156	82,190
Montana	70,152	81,668	761	487	2,754	1,094	1,465	678	75,132	83,927
Nevada	66,797	108,780	--	--	--	--	--	--	66,797	108,780
New Mexico	201,915	174,171	61,778	36,140	49,160	19,074	27,901	11,551	340,754	240,936
Utah	136,649	167,672	4,032	2,839	9,150	5,198	406	272	150,237	175,981
Wyoming	63,500	50,667	14,669	11,002	16,726	6,846	6,593	4,317	101,488	72,832

Total	1,025,348	1,173,035	93,184	61,110	85,534	37,255	63,001	31,659	1,267,067	1,303,059
Pacific:										
Alaska	73,999	70,620	1,229	585	15,972	6,404	150	86	91,350	77,695
California	1,661,751	2,654,675	14,125	13,560	78,967	58,116	15,893	10,918	1,770,736	2,737,269
Oregon	83,654	175,598	--	--	30	26	8,816	7,194	92,500	182,818
Washington	142,806	295,053	--	--	--	--	5,975	4,655	148,781	299,708
Total	1,962,210	3,195,946	15,354	14,145	94,969	64,546	30,834	22,853	2,103,367	3,297,490
Total United States	17,763,818	26,024,027	854,086	810,187	1,634,355	937,257	548,323	278,745	20,800,582	28,050,216

Note: All quantities at pressure base of 14.73 psia.

Table 8.—Quantity and value of natural gas delivered to consumers in 1976, by type of consumer and by State

Region and State	Residential			Commercial			Industrial[1]		Electric utilities		Other consumers[2]		Total	
	Quantity (million cubic feet)	Value (thousand dollars)	Number of consumers (thousands	Quantity (million cubic feet)	Value (thousand dollars)	Number of consumers (thousands)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)
New England:														
Connecticut	32,310	110,208	361	16,325	52,678	30	16,378	43,801	446	742	369	1,090	65,828	208,519
Maine, New Hampshire, Vermont	6,111	16,377	66	3,443	9,497	6	3,549	8,045	71	107	371	618	13,545	34,644
Massachusetts	95,107	346,380	979	34,208	107,194	67	20,261	50,644	2,488	4,394	3,555	8,997	155,619	517,609
Rhode Island	12,329	41,425	150	2,895	9,805	7	4,826	11,056	635	907	--	--	20,685	63,193
Total	145,857	514,390	1,556	56,871	179,174	110	45,014	113,546	3,640	6,150	4,295	10,705	255,677	823,965
Middle Atlantic:														
New Jersey	147,508	463,175	1,637	75,554	221,333	179	73,046	159,094	10,016	14,453	14,909	29,087	321,033	887,142
New York	339,949	975,565	3,741	131,912	315,590	233	103,907	163,654	5,293	6,558	11,618	21,623	592,679	1,482,990
Pennsylvania	290,439	620,959	2,134	116,747	201,972	144	273,464	370,270	481	641	7,770	12,331	688,901	1,206,173
Total	777,896	2,059,699	7,512	324,213	738,895	556	450,417	693,018	15,790	21,652	34,297	63,041	1,602,613	3,576,305
East North Central:														
Illinois	507,935	964,061	2,931	243,491	399,981	227	373,424	546,693	30,549	44,876	3,168	4,473	1,158,567	1,960,084
Indiana	152,860	259,042	997	65,056	98,728	91	196,677	212,411	3,157	3,653	2,425	2,324	420,175	576,158
Michigan	339,417	644,553	2,086	175,097	319,727	167	297,446	460,446	53,509	82,297	3,123	4,950	868,592	1,511,973
Ohio	440,190	780,457	2,555	172,358	279,079	196	370,687	516,738	5,191	8,077	7,034	11,824	995,460	1,596,175
Wisconsin	122,786	259,078	884	55,132	95,378	78	120,371	168,279	11,986	13,976	2,570	3,387	312,845	540,098
Total	1,563,188	2,907,191	9,453	711,134	1,192,893	759	1,358,605	1,904,567	104,392	152,879	18,320	26,958	3,755,639	6,184,488
West North Central:														
Iowa	89,676	144,558	562	60,642	80,010	63	122,342	123,443	25,805	23,947	4,092	3,804	302,557	375,762
Kansas	101,330	150,171	623	55,640	61,649	61	140,116	113,774	122,366	92,998	1,670	1,256	421,122	419,848
Minnesota	105,760	183,839	671	54,522	82,592	63	120,134	135,631	13,368	10,547	22,459	26,030	316,243	438,639
Missouri	160,198	272,176	1,064	86,617	120,917	82	91,074	90,710	25,298	18,695	11,818	12,362	375,005	514,860
Nebraska	54,965	75,093	344	39,683	47,205	53	64,267	54,498	19,575	15,406	9,030	9,012	187,520	201,214
North Dakota	10,182	18,228	68	12,075	16,276	9	2,673	3,563	43	37	127	238	25,100	38,342
South Dakota	14,510	21,780	83	13,310	15,280	11	8,078	5,865	1,244	1,112	2,034	2,096	39,176	46,133
Total	536,621	865,845	3,415	322,489	423,929	342	548,684	527,484	207,699	162,742	51,230	54,799	1,666,723	2,034,798

South Atlantic:														
Delaware	7,380	19,254	77	3,078	6,081	5	6,427	9,391	2,297	3,994	--	--	19,182	38,720
Florida	16,839	47,368	371	29,882	59,047	44	98,843	104,454	125,481	84,072	9,799	9,192	280,844	304,133
Georgia	86,356	146,355	835	43,306	60,003	66	120,496	133,148	4,663	4,551	3,045	4,073	257,866	348,130
Maryland and District of Columbia	87,408	224,994	851	36,617	80,226	63	43,528	70,559	232	301	5,805	11,247	173,590	387,327
North Carolina	33,727	71,930	326	19,398	39,707	45	44,616	75,118	6	6	644	1,172	98,391	187,933
South Carolina	33,231	76,132	240	26,230	42,545	24	73,501	95,110	3,793	3,471	8,832	9,415	145,587	226,673
Virginia	52,491	133,117	408	24,129	50,547	32	32,786	47,696	483	526	10,758	15,578	120,647	247,464
West Virginia	51,434	85,792	385	19,359	29,484	34	63,192	81,897	290	190	1,103	1,266	135,378	198,629
Total	368,866	804,942	3,493	201,999	367,640	313	483,389	617,373	137,245	97,111	39,986	51,943	1,231,485	1,939,009
East South Central:														
Alabama	56,869	113,112	552	32,704	52,948	43	119,817	132,038	3,935	4,419	1,746	2,021	215,071	304,538
Kentucky	96,351	127,196	559	50,735	58,293	52	70,640	76,221	135	129	6,468	7,348	224,329	269,187
Mississippi	26,584	45,506	287	13,365	18,667	30	84,157	88,197	32,808	33,563	6,849	7,419	163,763	193,352
Tennessee	43,749	70,480	400	35,042	50,932	50	114,526	134,454	176	163	3,202	3,807	196,695	259,836
Total	223,553	356,294	1,798	131,846	180,840	175	389,140	430,910	37,054	38,274	18,265	20,595	799,858	1,026,913
West South Central:														
Arkansas	49,348	60,550	418	33,392	34,180	54	136,109	110,657	15,972	12,298	619	429	235,440	218,114
Louisiana	95,457	149,963	846	27,870	34,581	63	901,750	851,252	365,693	302,859	15,697	13,280	1,406,467	1,351,935
Oklahoma	82,078	122,871	675	43,175	50,216	70	191,035	170,194	330,982	281,335	1,687	2,097	648,957	626,713
Texas	235,637	468,211	2,984	83,020	143,376	268	1,423,829	1,866,639	1,378,483	1,345,399	52,432	49,181	3,173,401	3,872,806
Total	462,520	801,595	4,923	187,457	262,353	455	2,652,723	2,998,742	2,091,130	1,941,891	70,435	64,987	5,464,265	6,069,568
Mountain:														
Arizona	40,267	85,247	523	33,022	48,014	45	54,536	50,119	24,338	20,979	3,741	4,439	155,904	208,798
Colorado	107,355	136,126	701	71,345	79,978	86	62,423	49,633	42,167	33,987	4,614	2,713	287,904	302,437
Idaho	12,512	28,039	98	8,742	18,009	14	21,169	32,706	104	88	--	--	42,527	78,842
Montana	23,525	32,095	161	15,490	18,389	20	28,087	28,008	709	430	2,341	2,746	70,152	81,668
Nevada	10,670	21,798	118	9,495	17,729	5	12,633	18,033	25,105	36,352	8,894	14,868	66,797	108,780
New Mexico	36,476	49,717	238	18,639	21,304	25	63,507	44,264	68,224	44,073	15,069	14,813	201,915	174,171
Utah	66,417	91,589	276	14,159	22,031	24	52,746	50,899	2,805	2,771	522	382	136,649	167,672
Wyoming	11,703	13,856	69	8,371	6,644	8	42,089	29,210	556	445	781	512	63,500	50,667
Total	308,925	458,467	2,184	179,263	232,098	227	337,190	302,872	164,008	139,125	35,962	40,473	1,025,348	1,173,035

See footnotes at end of table.

Table 8.—Quantity and value of natural gas delivered to consumers in 1976, by type of consumer and by State —Continued

Region and State	Residential			Commercial			Industrial[1]		Electric utilities		Other consumers[2]		Total	
	Quantity (million cubic feet)	Value (thousand dollars)	Number of consumers (thousands	Quantity (million cubic feet)	Value (thousand dollars)	Number of consumers (thousands)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)
Pacific:														
Alaska	10,917	18,046	28	8,767	11,257	4	26,687	23,164	22,204	14,677	5,424	3,476	73,999	70,620
California	599,631	1,061,947	6,331	213,418	341,979	371	547,371	801,132	294,909	442,530	6,422	7,087	1,661,751	2,654,675
Oregon	21,038	56,427	234	13,995	33,210	30	48,620	85,960	1	1	--	--	83,654	175,598
Washington	32,348	87,178	311	31,141	69,880	41	78,806	137,284	--	--	511	711	142,806	295,053
Total	663,934	1,223,598	6,904	267,321	456,326	446	701,484	1,047,540	317,114	457,208	12,357	11,274	1,962,210	3,195,946
Total United States	5,051,360	9,992,021	41,238	2,382,593	4,034,148	3,383	6,966,646	8,636,052	3,078,072	3,017,032	285,147	344,774	17,763,818	26,024,027

[1]Includes refinery fuel use of 918,856 million cubic feet and 28,033 million cubic feet for carbon black production.
[2]Includes deliveries to municipalities and public authorities for institutional heating, street lighting, etc.

Note: All quantities at pressure base of 14.73 psia.

Table 9.—Production of natural gas liquids at natural gas processing plants, natural gas processed and extraction loss in 1975 and 1976

(Million cubic feet at 14.73 psia at 60° F unless otherwise stated)

State	1975			1976		
	Total natural gas liquids and ethane production (thousand barrels)	Natural gas processed	Extraction loss (shrinkage)	Total natural gas liquids and ethane production (thousand barrels)	Natural gas processed	Extraction loss (shrinkage)
Alabama and Mississippi	875	29,694	1,261	845	25,517	1,181
Alaska, Montana, Utah	3,948	156,203	5,734	4,230	149,865	6,022
Arkansas	603	17,918	899	611	20,370	823
California	9,328	213,079	15,221	8,777	216,667	14,125
Colorado	6,563	136,090	9,620	8,409	175,624	11,944
Florida, Pennsylvania, West Virginia	12,977	765,597	18,496	15,644	854,064	22,210
Illinois and Kentucky	12,047	322,393	18,239	11,556	305,441	17,708
Kansas	29,858	1,367,949	42,763	30,201	1,389,850	40,975
Louisiana	135,522	5,831,487	189,541	118,779	5,749,783	172,584
Michigan	2,004	79,154	2,879	4,719	151,318	6,665
Nebraska, North Dakota, South Dakota	1,910	34,463	2,717	1,799	35,351	2,680
New Mexico	39,408	1,037,160	56,109	42,144	1,066,104	61,778
Oklahoma	40,475	1,033,003	60,008	42,514	1,072,992	52,087
Texas	291,470	6,509,132	435,571	287,092	6,253,159	428,635
Wyoming	8,970	215,104	13,224	9,725	251,846	14,669
Total United States	595,958	17,748,426	872,282	587,045	17,717,951	854,086

Table 10.—Comparison of actual and projected firm deliveries for heating season November through March

(Million cubic feet)

	Actual November 1976-March 1977	Projected November 1977-March 1978	Change
Alabama-Tennessee Natural Gas Co	11,445	10,440	-1,005
Algonquin Gas Transmission Co	81,774	82,911	1,137
Arkansas Louisiana Gas Co	148,704	152,935	4,231
Bluefield Gas Co	832	833	1
Caprock Pipeline Co	241	425	184
Cities Service Gas Co	204,517	208,810	4,293
Colorado Interstate Gas Co	182,816	192,433	9,617
Columbia Gas Transmission Corp	636,799	653,180	16,381
Commercial Pipeline Co., Inc	289	289	--
Consolidated Gas Supply Corp	350,253	321,752	-28,501
East Tennessee Natural Gas Co	30,141	30,790	649
Eastern Shore Natural Gas Co	1,813	1,784	-29
El Paso Natural Gas Co	453,175	392,276	-60,899
Florida Gas Transmission Co	23,100	20,911	-2,189
Granite State Gas Transmission, Inc	2,098	2,132	34
Great Lakes Gas Transmission Co	36,830	36,723	-107
Inter-City Minnesota Pipelines, Ltd	3,597	3,464	-133
Kansas-Nebraska Natural Gas Co., Inc	42,020	43,477	1,457
Kentucky-West Virginia Gas Co	10,160	12,848	2,688
Lawrenceburg Gas Transmission Corp	1,488	1,488	--
Louisiana-Nevada Transit Co	1,553	1,610	57
McCullock Interstate Gas Corp	1,553	1,358	-195
Michigan Wisconsin Pipe Line Co	415,769	409,488	-6,281
Mid Louisiana Gas Co	13,942	13,253	-689
Midwestern Gas Transmission Co	129,227	119,750	-9,477
Mississippi River Transmission Corp	132,590	131,158	-1,432
Montana-Dakota Utilities Co	25,086	25,833	747
National Fuel Gas Supply Corp	132,158	122,434	-9,724
Natural Gas Pipeline Co. of America	486,260	473,703	-12,557
North Penn Gas Co	16,536	15,424	-1,112
Northern Natural Gas Co	355,951	340,213	-15,738
Northwest Pipeline Corp	189,690	201,733	12,043
Pacific Gas Transmission Co	158,882	153,839	-5,043
Panhandle Eastern Pipeline Co	277,171	272,460	-4,711
South Georgia Natural Gas Co	7,136	8,137	1,001
South Texas Natural Gas Gathering Co	12,841	9,415	-3,426
Southern Natural Gas Co	258,030	257,141	-889
Tennessee Gas Pipeline Co	471,212	432,100	-39,112
Tennessee Natural Gas Lines, Inc	9,512	13,388	3,876
Texas Eastern Transmission Corp	358,604	391,484	32,880
Texas Gas Pipe Line Corp	1,057	816	-241
Texas Gas Transmission Corp	273,847	270,017	-3,830
Transcontinental Gas Pipe Line Corp	311,509	322,189	10,680
Transwestern Pipeline Co	99,884	85,490	-14,394
Trunkline Gas Co	161,463	159,249	-2,214
United Gas Pipe Line Co	389,833	365,202	-24,631
Valley Gas Transmission, Inc	2,959	2,360	-599
West Texas Gathering Co	37,652	24,615	-13,037
Western Gas Interstate Co	3,044	3,804	760
Western Transmission Corp	870	793	-77
Total	6,957,913	6,798,357	-159,556
Pipeline to Pipeline Transactions	1,242,414	1,252,745	10,331
Net total	5,715,499	5,545,612	-169,887

Source: Federal Power Commission.

Table 11.—Comparison of actual firm requirements and firm curtailments for year April 1976 through March 1977 with projections for year April 1977 through March 1978

(Million cubic feet)

	Total for year April 1976-March 1977			Total for year April 1977-March 1978		
	Actual			Projected		
	Firm requirements	Volume curtailed	Percent curtailed	Firm requirements	Curtailment	Percent curtailed
Alabama-Tennessee Natural Gas Co	29,758	2,793	9.39	31,969	6,137	19.20
Algonquin Gas Transmission Co	151,292	12,678	8.38	143,126	4,790	3.35
Arkansas Louisiana Gas Co	517,169	207,403	40.10	530,555	227,606	42.90
Bluefield Gas Co	1,218	--	--	1,160	--	--
Caprock Pipeline Co	860	--	--	796	--	--
Cities Service Gas Co	577,127	156,108	27.05	589,793	170,968	28.99
Colorado Interstate Gas Co	352,686	--	--	362,935	--	--
Columbia Gas Transmission Corp	1,419,987	325,351	22.91	1,447,526	408,656	28.23
Commercial Pipeline Co., Inc	398	--	--	398	--	--
Consolidated Gas Supply Corp	745,931	108,331	14.52	691,165	92,473	13.38
East Tennessee Natural Gas Co	81,290	24,374	29.98	81,290	24,374	29.98
Eastern Shore Natural Gas Co	6,703	2,461	36.72	6,385	3,200	50.12
El Paso Natural Gas Co	1,398,096	281,923	20.17	1,422,184	454,202	31.94
Florida Gas Transmission Co	40,523	--	--	38,697	--	--
Granite State Gas Transmission, Inc	3,632	--	--	3,717	--	--
Great Lakes Gas Transmission Co	88,888	--	--	88,741	--	--
Inter-City Minnesota Pipelines, Ltd	7,440	--	--	7,026	--	--
Kansas-Nebraska Natural Gas Co., Inc	91,955	--	--	89,927	--	--
Kentucky-West Virginia Gas Co	24,753	--	--	30,137	--	--
Lawrenceburg Gas Transmission Corp	5,523	1,980	35.85	5,523	1,980	35.85
Louisiana-Nevada Transit Co	3,911	339	8.67	4,626	735	15.89
McCulloch Interstate Gas Corp	4,642	--	--	3,711	--	--
Michigan Wisconsin Pipe Line Co	860,598	90,837	10.56	835,945	102,079	12.21
Mid Louisiana Gas Co	32,007	7,631	23.84	31,365	6,624	21.12
Midwestern Gas Transmission Co	347,391	37,455	10.78	349,497	52,344	14.98
Mississippi River Transmission Corp	226,277	583	0.26	220,709	--	--
Montana-Dakota Utilities Co	37,657	--	--	40,158	--	--
National Fuel Gas Supply Corp	219,331	11,157	5.09	228,821	31,486	13.76
Natural Gas Pipeline Co of America	1,214,068	247,872	20.42	1,216,631	281,448	23.13
North Penn Gas Co	27,782	--	--	26,860	--	--
Northern Natural Gas Co	823,441	98,121	11.92	855,974	174,323	20.37
Northwest Pipeline Corp	425,935	26,678	6.26	441,122	10,429	2.36
Pacific Gas Transmission Co	374,613	--	--	333,662	--	--
Panhandle Eastern Pipeline Co	733,806	191,134	26.05	729,476	183,669	25.18
South Georgia Natural Gas Co	12,665	124	0.98	14,960	372	2.49
South Texas Natural Gas Gathering Co	30,648	--	--	24,165	--	--
Southern Natural Gas Co	659,235	127,772	19.38	305,180	48,039	15.74
Tennessee Gas Pipeline Co	1,317,191	214,061	16.25	1,317,092	261,537	19.86
Tennessee Natural Gas Lines, Inc	31,956	5,322	16.65	34,506	9,192	26.64
Texas Eastern Transmission Corp	1,021,804	255,690	25.02	1,017,762	154,753	15.21
Texas Gas Pipe Line Corp	2,402	--	--	1,996	--	--
Texas Gas Transmission Corp	775,617	219,650	28.32	771,162	225,261	29.21
Transcontinental Gas Pipe Line Corp	1,072,557	463,058	43.17	1,093,798	544,103	49.74
Transwestern Pipeline Co	366,690	117,741	32.11	366,671	141,733	38.65
Trunkline Gas Co	594,820	222,150	37.35	593,217	189,737	31.98
United Gas Pipe Line Co	1,601,167	773,984	48.34	1,605,928	806,342	50.21
Valley Gas Transmission, Inc	7,252	--	--	6,011	--	--
West Texas Gathering Co	92,457	--	--	64,652	--	--
Western Gas Interstate Co	7,553	370	4.90	11,299	400	3.54
Western Transmission Corp	1,937	--	--	1,916	--	--
Total	18,472,639	4,235,131	22.93	18,121,922	4,618,992	25.49
Net Requirements	14,705,113	XX	XX	14,302,000	XX	XX
Net Curtailments	XX	3,379,672	XX	XX	3,800,488	XX
Net Curtailments as a percent of net requirements	XX	XX	22.98	XX	XX	26.57

XX Not applicable.

Source: Federal Power Commission.

Table 12.—Comparison of actual and firm requirements and firm curtailments for heating season November 1976 through March 1977 with projections for year November 1977 through March 1978

(Million cubic feet)

	Heating season November 1976-March 1977			Heating season November 1977-March 1978		
	Actual			Projected		
	Firm requirements	Volume curtailed	Percent curtailed	Firm requirements	Curtailment	Percent curtailed
Alabama-Tennessee Natural Gas Co	14,017	2,572	18.35	16,126	5,686	35.26
Algonquin Gas Transmission Co	91,160	9,386	10.30	87,701	4,790	5.46
Arkansas Louisiana Gas Co	254,595	105,891	41.59	248,999	96,064	38.58
Bluefield Gas Co.	832	--	--	833	--	--
Caprock Pipeline Co	241	--	--	425	--	--
Cities Service Gas Co	310,116	105,599	34.05	303,541	94,731	31.21
Colorado Interstate Gas Co	182,816	--	--	192,433	--	--
Columbia Gas Transmission Corp	832,867	196,068	23.54	848,246	195,066	23.00
Commercial Pipeline Co., Inc.	289	--	--	289	--	--
Consolidated Gas Supply Corp	395,552	45,299	11.45	359,023	37,271	10.38
East Tennessee Natural Gas Co	40,577	10,436	25.72	41,508	10,718	25.82
Eastern Shore Natural Gas Co	3,455	1,642	47.53	3,456	1,672	48.38
El Paso Natural Gas Co	597,100	143,925	24.10	608,062	215,786	35.49
Florida Gas Transmission Co	23,100	--	--	20,911	--	--
Granite State Gas Transmission, Inc	2,098	--	--	2,132	--	--
Great Lakes Gas Transmission Co	36,830	--	--	36,723	--	--
Inter-City Minnesota Pipelines, Ltd	3,597	--	--	3,464	--	--
Kansas-Nebraska Natural Gas Co., Inc	42,020	--	--	43,477	--	--
Kentucky-West Virginia Gas Co	10,160	--	--	12,848	--	--
Lawrenceburg Gas Transmission Corp	2,298	810	35.25	2,298	810	35.25
Louisiana-Nevada Transit Co	1,870	317	16.95	2,172	562	25.87
McCulloch Interstate Gas Corp	1,553	--	--	1,358	--	--
Michigan Wisconsin Pipe Line Co	458,124	42,355	9.25	451,953	42,465	9.40
Mid Louisiana Gas Co	17,521	3,579	20.43	16,225	2,972	18.32
Midwestern Gas Transmission Co	149,454	20,227	13.53	150,556	30,806	20.46
Mississippi River Transmission Corp	133,173	583	0.44	131,158	--	--
Montana-Dakota Utilities Co	25,086	--	--	25,833	--	--
National Fuel Gas Supply Corp	143,315	11,157	7.78	142,191	19,757	13.89
Natural Gas Pipeline Co. of America	517,343	31,083	6.01	522,525	48,822	9.34
North Penn Gas Co	16,536	--	--	15,424	--	--
Northern Natural Gas Co	415,167	59,216	14.26	405,155	64,942	16.03
Northwest Pipeline Corp	215,195	25,505	11.85	211,238	9,505	4.50
Pacific Gas Transmission Co	158,882	--	--	153,839	--	--
Panhandle Eastern Pipeline Co	355,846	78,675	22.11	352,818	80,358	22.78
South Georgia Natural Gas Co	7,257	121	1.67	8,319	182	2.19
South Texas Natural Gas Gathering Co	12,841	--	--	9,415	--	--
Southern Natural Gas Co	302,712	44,682	14.76	305,180	48,039	15.74
Tennessee Gas Pipeline Co	572,514	101,302	17.69	569,694	137,594	24.15
Tennessee Natural Gas Lines, Inc	12,359	2,847	23.04	19,514	6,126	31.39
Texas Eastern Transmission Corp	451,576	92,972	20.59	451,853	60,369	13.36
Texas Gas Pipe Line Corp	1,057	--	--	816	--	--
Texas Gas Transmission Corp	357,252	83,405	23.35	353,419	83,402	23.60
Transcontinental Gas Pipe Line Corp	506,093	194,584	38.45	537,889	215,700	40.10
Transwestern Pipeline Co	151,444	51,560	34.05	151,446	65,956	43.55
Trunkline Gas Co	248,137	86,674	34.93	247,543	88,294	35.67
United Gas Pipe Line Co	706,265	316,432	44.80	705,223	340,021	48.21
Valley Gas Transmission, Inc	2,959	--	--	2,360	--	--
West Texas Gathering Co	37,652	--	--	24,615	--	--
Western Gas Interstate Co	3,414	370	10.84	4,204	400	9.51
Western Transmission Corp	870	--	--	793	--	--
Total	8,827,187	1,869,274	21.18	8,807,223	2,008,866	22.81
Net Requirements	7,242,763	XX	XX	7,204,682	XX	XX
Net Curtailments	XX	1,527,264	XX	XX	1,659,070	XX
Net curtailments as a percent of net requirements	XX	XX	21.09	XX	XX	23.03

XX Not applicable.

Source: Federal Power Commission.

Table 13.—Comparison of actual interruptible sales and curtailments for year April 1976 through March 1977 with projected requirements and deficiencies for year April 1977 through March 1978

(Million cubic feet)

	Actual-year April 1976-March 1977			Projected-year April 1977-March 1978		
	Interruptible requirement	Volume curtailed	Percent curtailed	Interruptible requirement	Volume curtailed	Percent curtailed
Alabama-Tennessee Natural Gas Co	10,898	9,991	91.68	10,763	10,763	100.00
Algonquin Gas Transmission Co	14,432	14,432	100.00	11,232	11,232	100.00
Arkansas Louisiana Gas Co	8,331	8,331	100.00	--	--	--
Bluefield Gas Co	144	--	--	119	--	--
Colorado Interstate Gas Co	36,209	3,655	10.09	23,644	4,565	19.31
East Tennessee Natural Gas Co	21,424	18,927	88.35	21,987	20,603	93.71
Eastern Shore Natural Gas Co	1,470	1,286	87.48	1,472	1,472	100.00
Florida Gas Transmission Co	118,817	67,700	56.98	126,982	49,260	38.79
Granite State Gas Transmission, Inc	502	202	40.24	455	246	54.07
Kansas-Nebraska Natural Gas Co., Inc	33,353	9,150	27.43	32,905	13,220	40.18
Louisiana-Nevada Transit Co	502	--	--	78	78	100.00
Mid Louisiana Gas Co	1,296	1,296	100.00	1,278	1,278	100.00
Mississippi River Transmission Corp	49,420	42,934	86.88	57,898	45,086	77.87
Montana-Dakota Utilities Co	20,898	841	4.02	24,540	6,882	28.04
Natural Gas Pipeline Co. of America	21	--	--	15	--	--
Northern Natural Gas Co	470	--	--	--	--	--
Northwest Pipeline Corp	7,054	6,748	95.66	8,668	6,767	78.07
Panhandle Eastern Pipeline Co	64,085	31,591	49.30	54,457	25,331	46.52
South Georgia Natural Gas Co	20,281	10,426	51.41	19,590	12,243	62.50
Southern Natural Gas Co	285,693	263,242	92.14	262,046	241,499	92.16
Tennessee Natural Gas Lines, Inc	4,054	2,677	66.03	3,740	3,740	100.00
Texas Gas Transmission Corp	4,075	4,075	100.00	4,080	4,076	99.90
Transwestern Pipeline Co	811	--	--	811	--	--
Total	704,245	497,504	70.64	666,760	458,341	68.74
Net requirements and net curtailments	668,618	474,214	70.92	643,662	443,344	68.88

Source: Federal Power Commission.

Table 14.—Comparison of actual interruptible sales and curtailments for heating season November through March 1977 with projected requirements and deficiencies for year April 1977 through March 1978

(Million cubic feet)

	Actual-year November 1976-March 1977			Projected-year November 1977-March 1978		
	Interruptible requirement	Volume curtailed	Percent curtailed	Interruptible requirement	Volume curtailed	Percent curtailed
Alabama-Tennessee Natural Gas Co	2,608	1,922	73.70	2,479	2,479	100.00
Algonquin Gas Transmission Co	--	--	--	--	--	--
Arkansas Louisiana Gas Co	--	--	--	--	--	--
Bluefield Gas Co	38	--	--	12	--	--
Colorado Interstate Gas Co	5,757	3,584	62.26	5,298	4,565	86.17
East Tennessee Natural Gas Co	7,485	7,071	94.47	8,169	8,124	99.45
Eastern Shore Natural Gas Co	309	306	99.03	310	310	100.00
Florida Gas Transmission Co	45,713	28,461	62.26	49,942	22,182	44.42
Granite State Gas Transmission, Inc	180	151	83.89	180	160	88.89
Kansas-Nebraska Natural Gas Co., Inc	13,937	5,495	39.43	14,340	8,195	57.15
Louisiana-Nevada Transit Co	151	--	--	32	32	100.00
Mid Louisiana Gas Co	537	537	100.00	529	529	100.00
Mississippi River Transmission Corp	19,192	18,902	98.49	23,940	23,940	100.00
Montana-Dakota Utilities Co	10,895	673	6.18	12,540	3,108	24.79
Natural Gas Pipeline Co. of America	8	--	--	7	--	--
Northern Natural Gas Co	426	--	--	--	--	--
Northwest Pipeline Corp	6,452	6,412	99.38	7,997	6,743	84.32
Panhandle Eastern Pipeline Co	23,613	14,150	59.93	24,272	13,266	54.66
South Georgia Natural Gas Co	7,037	4,568	64.91	5,973	4,774	79.93
Southern Natural Gas Co	164,726	162,356	98.56	150,866	148,934	98.72
Tennessee Natural Gas Lines, Inc	1,440	1,060	73.61	1,349	1,349	100.00
Texas Gas Transmission Corp	1,223	1,223	100.00	1,227	1,224	99.76
Transwestern Pipeline Co	282	--	--	282	--	--
Total	312,009	256,871	82.33	309,744	249,914	80.68
Net requirements and net curtailments	301,990	247,328	81.90	300,249	240,555	80.12

Source: Federal Power Commission.

Table 15.—Marketed production, interstate shipments and total consumption of natural gas in the United States, 1976

(Million cubic feet)

State and region	Marketed production	Interstate movements: Receipts	Interstate movements: Deliveries	Interstate movements: Net receipts or deliveries (-)	Change in underground storage	Adjustments[1]	Consumption
New England:							
Connecticut	--	144,040	78,530	65,510	--	-345	65,855
Maine, Vermont, New Hampshire	--	13,889	--	13,889	--	344	13,545
Massachusetts	--	185,894	28,932	156,962	--	715	156,247
Rhode Island	--	83,390	63,648	19,742	--	-955	20,697
Total	--	427,213	171,110	256,103	--	-241	256,344
Middle Atlantic:							
New Jersey	--	705,482	375,966	329,516	--	7,981	321,535
New York	9,235	825,112	242,378	582,734	-10,590	6,626	595,933
Pennsylvania	89,386	1,728,941	1,178,012	550,929	-88,149	14,885	713,579
Total	98,621	3,259,535	1,796,356	1,463,179	-98,739	29,492	1,631,047
East North Central:							
Illinois	1,556	2,140,583	896,971	1,243,612	25,844	31,612	1,187,712
Indiana	192	1,663,876	1,239,222	424,654	-5,176	4,801	425,221
Michigan	119,262	742,482	7,461	735,021	-42,463	2,046	894,700
Ohio	88,891	2,512,997	1,634,534	878,463	-60,308	21,735	1,005,927
Wisconsin	--	473,612	157,996	315,616	--	462	315,154
Total	209,901	7,533,550	3,936,184	3,597,366	-82,103	60,656	3,828,714
West North Central:							
Iowa	--	1,325,699	991,843	333,856	5,256	17,175	311,425
Kansas	829,170	1,877,945	2,151,678	-273,733	-735	--	556,172
Minnesota	--	563,833	238,474	325,359	-560	5,763	320,156
Missouri	29	1,517,775	1,139,598	378,177	-2,484	432	380,258
Nebraska	2,511	1,341,096	1,138,711	202,385	3,731	2,272	198,893
North Dakota	31,470	15,530	1,403	14,127	--	1,999	43,598
South Dakota	--	41,498	1,385	40,113	--	906	39,207
Total	863,180	6,683,376	5,663,092	1,020,284	5,208	28,547	1,849,709

See footnotes at end of table.

Table 15.—Marketed production, interstate shipments and total consumption of natural gas in the United States, 1976 —Continued

(Million cubic feet)

State and region	Marketed production	Interstate movements: Receipts	Interstate movements: Deliveries	Interstate movements: Net receipts or deliveries (-)	Change in underground storage	Adjustments[1]	Consumption
South Atlantic:							
Delaware	--	20,179	1,178	19,001	--	-181	19,182
Florida	43,165	259,717	--	259,717	--	--	302,882
Georgia	--	1,047,507	786,275	261,232	--	-88	261,320
Maryland and District of Columbia	75	634,812	457,011	177,801	-2,292	3,896	176,272
North Carolina	--	600,683	495,998	104,685	--	3,510	101,175
South Carolina	--	763,722	600,683	163,039	--	14,050	148,989
Virginia	6,937	755,515	633,272	122,243	--	5,671	123,509
West Virginia	153,322	1,195,503	1,259,379	-63,876	-59,906	-9,655	159,007
Total	203,499	5,277,638	4,233,796	1,043,842	-62,198	17,203	1,292,336
East South Central:							
Alabama	41,427	2,686,071	2,496,561	189,510	--	4,297	226,640
Kentucky	66,137	3,407,936	3,219,540	188,396	-5,520	8,855	251,198
Mississippi	70,762	5,233,400	5,112,309	121,091	-11,018	3,229	199,642
Tennessee	47	3,631,175	3,415,042	216,133	--	3,854	212,326
Total	178,373	14,958,582	14,243,452	715,130	-16,538	20,235	889,806
West South Central:							
Arkansas	109,533	2,349,241	2,192,542	156,699	472	15,996	249,764
Louisiana	7,006,596	985,150	5,770,752	-4,785,602	36,857	-32,152	2,216,289
Oklahoma	1,726,513	1,245,596	2,161,079	-915,483	-3,758	2,591	812,197
Texas	7,191,859	634,907	3,397,017	-2,762,110	11,560	14,247	4,403,942
Total	16,034,501	5,214,894	13,521,390	-8,306,496	45,131	682	7,682,192
Mountain:							
Arizona	262	1,265,930	1,095,462	170,468	--	-545	171,275
Colorado	183,972	269,218	137,180	132,038	3,531	-1,749	314,228
Idaho	--	534,386	487,023	47,363	--	207	47,156
Montana	42,563	43,822	22,492	21,330	-7,341	-3,898	75,132
Nevada	--	67,300	--	67,300	--	503	66,797
New Mexico	1,230,976	630,215	1,512,447	-882,232	-270	8,260	340,754
Utah	57,416	220,219	122,503	97,716	228	4,667	150,237
Wyoming	328,768	104,394	322,223	-217,829	-678	10,124	101,488

Total	1,843,957	3,135,484	3,699,330	-563,846	-4,525	17,569	1,267,067
Pacific:							
Alaska	166,072	--	49,780	-49,780	--	24,942	91,350
California	354,334	1,474,658	--	1,474,658	45,264	12,992	1,770,736
Oregon	--	546,601	451,649	94,952	--	2,452	92,500
Washington	--	649,387	495,722	153,665	3,173	1,711	148,781
Total	520,406	2,670,646	997,151	1,673,495	48,437	42,097	2,103,367
Total United States	19,952,438	[2]49,160,918	[3]48,261,861	899,057	-165,327	216,240	20,800,582

[1]Includes transmission losses, changes in above ground storage, and gas unaccounted for.

[2]Includes receipts from Canada of 440,276 MMcf into Idaho; 213,243 MMcf into Washington; 254,858 MMcf into Minnesota; 35,633 MMcf into Montana; 5,537 MMcf into New York; 4,066 MMcf into Vermont; and receipts from Algeria of 10,155 MMcf into Massachusetts.

[3]Includes deliveries to Canada of 7,461 MMcf from Michigan; 45 MMcf from Montana, and into Mexico of 5,760 MMcf from Texas; 1,665 MMcf from Arizona; and liquefied natural gas exports of 49,780 MMcf to Japan from Alaska.

Table 16.—Estimated total proved reserves of natural gas in the United States

(Million cubic feet at 14.73 psia at 60° F)

State	Reserves as of Dec. 31, 1975	Changes in reserves during 1976: Revisions	Extensions	New field discoveries	New reservoir discoveries in old fields	Net change in underground storage[1]	Production[2]	Reserves as of December 31, 1976: Total gas	Non-associated	Associated-dissolved	Underground storage[3]	Net change in reserves
Alabama	770,981	-88,318	47,042	--	1,475	--	24,027	707,153	670,680	36,473	--	-63,828
Alaska	32,050,749	102,373	199	--	--	--	223,769	31,929,552	5,614,597	26,314,955	--	-121,197
Arizona	1,559	623	--	--	--	--	290	1,892	384	1,508	--	333
Arkansas	1,993,273	-172,351	21,965	4,589	149	472	119,826	1,728,271	1,579,315	124,309	24,647	-265,002
California[4]	5,484,027	-23,711	109,310	27,100	8,100	50,027	312,822	5,342,031	2,052,641	2,911,093	378,297	-141,996
Colorado	1,893,017	52,083	105,977	11,979	--	3,078	178,349	1,887,785	1,670,792	184,621	32,372	-5,232
Florida	266,904	36,298	504	--	--	--	46,204	257,502	--	257,502	--	-9,402
Illinois	380,804	-161	398	--	--	-2,835	1,330	376,876	1,125	2,508	373,243	-3,928
Indiana	59,839	-710	--	--	--	-13,399	329	45,401	975	17	44,409	-14,438
Iowa	96,435	--	--	--	--	2,101	--	98,536	--	--	98,536	2,101
Kansas	12,661,181	-121,770	218,893	14,112	3,030	-109	824,773	11,950,564	11,695,754	150,063	104,747	-710,617
Kentucky	812,630	-1,296	21,362	903	951	-4,502	58,504	771,544	601,714	42,742	127,088	-41,086
Louisiana[4 5]	61,309,423	543,571	1,004,574	402,056	1,177,081	40,151	6,975,100	57,501,756	47,460,069	9,790,239	251,448	-3,807,667
Maryland	42,588	--	--	--	--	-3,149	72	39,367	4,042	--	35,325	-3,221
Michigan	1,606,749	96,725	--	63,463	--	-41,822	126,969	1,598,146	528,778	524,475	544,893	-8,603
Minnesota	3,125	--	--	--	--	-560	--	2,565	--	--	2,565	-560
Mississippi	1,207,627	-134,629	40,529	35,338	3,343	-11,018	79,876	1,061,314	890,012	101,204	70,098	-146,313
Missouri	17,527	42	--	--	--	-2,484	25	15,060	25	--	15,035	-2,467
Montana	929,986	145,327	72,569	16,094	1,020	-7,341	51,385	1,106,270	876,452	67,435	162,383	176,284
Nebraska	55,818	787	121	366	--	5,794	3,728	59,158	9,520	7,988	41,650	3,340
New Mexico	11,759,294	973,874	364,857	32,828	5,785	-211	1,219,810	11,916,617	9,489,996	2,396,986	29,635	157,323
New York	215,843	100	38,575	575	725	-10,590	9,199	236,029	134,163	97	101,769	20,186
North Dakota	416,848	8,068	2,801	2,050	182	--	24,005	405,944	5,404	400,540	--	-10,904
Ohio	1,354,010	--	142,945	1,610	2,145	-60,359	89,770	1,350,581	863,684	162,266	324,631	-3,429
Oklahoma	13,083,028	-133,766	933,052	182,507	26,117	-1,462	1,654,143	12,435,333	9,792,240	2,424,755	218,338	-647,695
Pennsylvania	1,682,460	--	138,125	3,400	1,350	-83,463	89,974	1,651,898	1,127,467	11,570	512,861	-30,562
South Dakota	193	39	24	31	--	--	44	243	--	243	--	50
Tennessee	9,680	--	1,600	900	800	--	47	12,933	12,660	273	--	3,253
Texas[4]	71,036,854	-2,536,009	1,748,945	566,505	718,770	12,266	6,895,921	64,651,410	48,046,816	16,436,219	168,375	-6,385,444
Utah	917,433	-44,458	13,975	--	61	228	57,377	829,862	442,589	383,763	3,510	-87,571
Virginia	47,465	10,000	5,850	--	--	--	6,922	56,393	56,393	--	--	8,928
Washington	18,331	--	--	--	--	2,101	--	20,432	--	--	20,432	2,101
West Virginia	2,311,336	2	164,774	4,258	3,318	-59,792	150,623	2,273,273	1,910,381	49,717	313,175	-38,063
Wyoming	3,703,159	90,148	138,741	50,349	39,465	-672	316,807	3,704,383	3,099,087	551,662	53,634	1,224

Total United States	228,200,176	-1,197,119	5,337,707	1,421,013	1,993,867	-187,550	19,542,020	216,026,074	148,637,755	63,335,223	4,053,096	-12,174,102
Gulf of Mexico[6]	37,332,642	1,819,356	696,738	426,319	981,206	--	4,153,175	37,103,086	32,544,127	4,558,959	--	-229,556

[1]The net difference between gas stored in and gas withdrawn from underground storage reservoirs, inclusive of adjustments and natural gas transferred from other reserve categories. (Adjustments include change of reporting basis starting in 1974 to report only gas reserves considered recoverable, in effect, reducing gas reserves by 1,024,140 MMcf that would have been reported since 1972 using the former basis).

[2]Preliminary net production.

[3]Proved recoverable gas contained in underground gas storage reservoirs, including natural and net injected gas. (First reported on a recoverable basis in 1973).

[4]Includes offshore.

[5]Reported quantities include reserves estimated to be recoverable from some reservoirs considered natural gas bearing based on electrical log, core data and other available engineering and geological data.

[6]Included with Louisiana and Texas.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 17.—Underground storage capacity, by State, December 31, 1976

State	Number of reservoirs	Total capacity (billion cubic feet)
Arkansas	6	54.4
California	8	399.7
Colorado	7	52.7
Illinois	34	786.8
Indiana	28	81.2
Iowa	9	213.0
Kansas	18	172.5
Kentucky	24	213.1
Louisiana	7	381.9
Maryland	1	62.0
Michigan	37	862.9
Minnesota	2	9.9
Mississippi	4	108.0
Missouri	2	31.0
Montana	5	196.8
Nebraska	2	93.1
New Mexico	2	45.9
New York	19	131.0
Ohio	23	503.0
Oklahoma	11	308.7
Pennsylvania	61	829.3
Texas	21	311.2
Utah	3	149.8
Washington	1	34.4
West Virginia	38	438.7
Wyoming	7	108.7
Total U.S.	380	6,579.7

Table 18.—Underground storage of natural gas in the U.S. and monthly stock changes during 1976

(Billion cubic feet)

	Beginning stocks[1]	Additions	Withdrawals	Net change	Ending stocks[1]
January	4,400	21	576	-555	3,845
February	3,845	62	368	-306	3,539
March	3,539	86	105	-19	3,520
April	3,520	177	69	108	3,628
May	3,628	261	34	227	3,855
June	3,855	317	28	289	4,144
July	4,144	290	9	281	4,425
August	4,425	317	14	303	4,728
September	4,728	268	21	247	4,975
October	4,975	133	123	10	4,985
November	4,985	41	292	-251	4,734
December	4,734	22	517	-495	4,239

[1]Injected gas only, natural gas in underground reservoirs is excluded.

Table 19.—Quantity and value of marketed production of natural gas in the United States

State	1975 Quantity (million cubic feet)[1]	1975 Value (thousand dollars)	1975 Average wellhead value (cents per Mcf)	1976 Quantity (million cubic feet)[1]	1976 Value (thousand dollars)	1976 Average wellhead value (cents per Mcf)
Alabama	37,814	32,898	87.0	41,427	40,806	98.5
Alaska	160,270	48,402	30.2	166,072	64,602	38.9
Arizona	208	58	28.0	262	74	28.2
Arkansas	116,237	40,334	34.7	109,533	58,052	53.0
California	318,308	222,816	70.0	354,334	333,074	94.0
Colorado	171,629	44,624	26.0	183,972	88,307	48.0
Florida	44,383	43,185	97.3	43,165	42,388	98.2
Illinois	1,440	1,008	70.0	1,556	1,533	98.5
Indiana	346	135	39.0	192	100	52.0
Kansas	843,625	145,103	17.2	829,170	348,251	42.0
Kentucky	60,511	32,676	54.0	66,137	36,375	55.0
Louisiana	7,090,645	2,999,179	42.3	7,006,596	3,223,034	46.0
Maryland	93	25	27.0	75	24	32.3
Michigan	102,113	64,740	63.4	119,262	106,739	89.5
Mississippi	74,345	36,875	49.6	70,762	50,241	71.0
Missouri	30	10	34.0	29	10	34.5
Montana	40,734	17,638	43.3	42,563	18,941	44.5
Nebraska	2,565	1,388	54.1	2,511	1,288	51.3
New Mexico	1,217,430	493,059	40.5	1,230,976	695,501	56.5
New York	7,628	5,645	74.0	9,235	10,436	113.0
North Dakota	24,786	5,701	23.0	31,470	10,699	34.0
Ohio	84,960	59,982	70.6	88,891	90,491	101.8
Oklahoma	1,605,410	513,731	32.0	1,726,513	866,710	50.2
Pennsylvania	84,676	57,156	67.5	89,386	61,229	68.5
Tennessee	27	12	43.0	47	24	71.0
Texas	7,485,764	3,885,112	51.9	7,191,859	5,163,755	71.8
Utah	55,354	26,570	48.0	57,416	28,995	50.5
Virginia	6,723	3,462	51.5	6,937	7,908	114.0
West Virginia	154,484	57,005	36.9	153,322	87,394	57.0
Wyoming	316,123	106,533	33.7	328,768	134,795	41.0
Total	20,108,661	8,945,062	44.5	19,952,438	11,571,776	58.0

[1]Marketed production of natural gas represents gross withdrawals less gas used for repressuring and quantities vented and flared.

Source: Figures based on reports received from State agencies.

Table 20.—Average wholesale prices for 14 large cities and adjacent areas

(Cents per Mcf)

Standard metropolitan statistical area	July 1, 1970	July 1, 1971	July 1, 1972[1]	July 1, 1973[1]	July 1, 1974[1]	July 1, 1975[1]	July 1, 1976[1]
Baltimore	43.98	52.60	53.22	54.51	65.21	96.40	108.34
Boston	65.76	76.17	76.73	83.61	114.10	133.14	185.31
Chicago	31.93	36.04	36.65	44.76	55.66	72.68	89.69
Cleveland	44.64	49.09	52.90	52.14	62.72	73.72	92.77
Detroit	39.91	41.48	47.34	51.21	58.51	82.14	107.34
Los Angeles[2]	34.63	38.78	40.74	42.25	50.53	74.57	82.09
Minneapolis-St. Paul	36.80	42.59	45.14	52.03	55.67	67.93	92.34
Newark (and New Jersey suburbs of New York)	43.45	47.18	53.61	56.91	77.02	97.84	116.88
New York	42.51	45.98	51.93	54.17	71.64	93.78	112.98
Philadelphia	43.42	46.90	53.28	56.64	76.53	95.80	117.25
Pittsburgh	43.44	49.78	49.26	48.24	65.07	75.30	93.65
St. Louis (Missouri portion only)	37.26	47.62	49.37	53.96	61.18	90.28	98.81
San Fransico-Oakland[2]	33.67	35.17	36.52	39.24	49.01	94.27	127.04
Washington, D.C	51.06	61.64	60.29	59.74	71.60	103.51	118.11

[1]Reflects contingent rates in effect subject to subsequent reduction and refunds as of July 1, of year indicated.
[2]Deliveries are not at city gates. Distributors must transport from State lines (California-Oregon and California-Arizona).

Source: Federal Power Commission.

Table 21.—Average price of residential heating gas by area 1969-77

(Dollars per 10 therms)

Standard metropolitan statistical area	January 1969	January 1970	January 1971	January 1972	January 1973	January 1974	January 1975	January 1976	January 1977
Atlanta	0.824	0.824	0.824	1.009	1.107	1.117	1.218	1.411	1.658
Baltimore	1.265	1.332	1.327	1.513	1.513	1.564	2.017	2.409	2.544
Boston	1.436	1.499	1.568	1.802	1.814	2.103	2.538	3.155	3.548
Buffalo	.905	.932	1.028	1.218	1.223	1.461	1.854	1.947	2.577
Chicago-Northwest Indiana	.895	.965	1.021	1.110	1.130	1.207	1.432	1.623	2.150
Cincinnati	.752	.799	.812	.943	.974	.992	1.328	1.555	2.237
Cleveland	.732	.747	.858	.896	.938	.928	1.229	1.405	1.710
Dallas	.755	.847	.849	.863	.890	.888	.914	1.512	2.045
Detroit	.850	.866	.873	.953	.998	1.155	1.350	1.869	2.271
Houston	.871	.875	.928	.957	1.000	1.042	1.499	2.229	2.821
Kansas City	.609	.681	.669	.717	.720	.771	.929	1.053	1.449
Milwaukee	1.101	1.247	1.272	1.350	.391	1.446	1.575	2.157	2.602
Minneapolis-St. Paul	.851	.877	.913	.998	1.073	1.119	1.354	1.439	1.646
New York-Northeast New Jersey	1.299	1.320	1.363	1.568	1.660	1.887	2.293	3.015	3.510
Philadelphia	1.380	1.381	1.430	1.459	1.531	1.714	2.009	2.380	2.506
Pittsburgh	.845	.880	.970	1.018	1.064	1.144	1.418	1.607	1.874
St. Louis	.842	.916	.979	1.093	1.097	1.173	1.454	1.654	1.878
San Francisco-Oakland	.610	.622	.714	.762	.840	.920	1.291	1.530	1.657
Seattle	1.150	1.159	1.159	1.249	1.270	1.530	1.886	2.421	2.634
Washington, D.C	1.315	1.362	1.360	1.505	1.569	1.599	2.149	2.482	3.060
Average	.844	.874	.920	1.010	1.047	1.133	1.379	1.943	2.319

Source: Bureau of Labor Statistics, Monthly release, "Retail Prices and Indexes of Fuels and Electricity" table 7; U.S. average table 2.

Table 22.—Liquefied natural gas (LNG) exports, in 1976[1]

	Phillips Petroleum Co.	Marathon Oil Co.	Total Exports
Volume shipped:			
Barrels ... 42 U.S. gallons	10,036,251	4,229,586	14,265,837
Mcf equivalent at 14.73 psia	34,998,822	14,780,647	49,779,469
Average Btu per cubic feet	1,010	1,010	1,010
Value:			
Total dollars	58,645,046	24,779,113	83,424,159
Average price ... cents per Mcf	167.56	167.65	167.59

[1]All shipments were to Japan from Port Nakiski, Alaska.

Source: Federal Power Commission.

Table 23.—Natural gas exports via pipeline: Volume, value, and unit cost, 1975-76

Exporting companies	Point of exit	Gas volume (thousand cubic feet at 14.73 psia and 60° F)		Percent change	Value (dollars)		Average price (cents per thousand cubic feet)	
		1975	1976		1975	1976	1975	1976
EXPORTS TO CANADA								
Interstate company:								
Panhandle Eastern Pipe Line Co	Detroit River-River Rouge, Mich	10,153,178	7,460,874	-26.5	7,918,872	7,897,884	77.99	105.86
Intrastate company:								
The Montana Power Co	Sweet Grass, Mont	66,173	44,804	-32.3	54,366	55,623	82.16	124.15
Total Canada[1]		10,219,351	7,505,678	-26.6	7,973,238	7,953,507	78.02	105.97
EXPORTS TO MEXICO								
Interstate company:								
El Paso Natural Gas Co	Naco, Ariz	3,223,030	1,665,497	-48.3	2,473,125	1,446,213	76.73	86.83
Intrastate companies:								
Del Norte Natural Gas Co	El Paso, Tex	3,713,297	3,876,030	4.4	3,107,474	3,858,401	83.69	99.55
Entex, Inc	Laredo, Tex	1,183,620	868,200	-26.7	2,045,010	1,972,413	172.78	227.18
Texas Gas Utilities Co	Eagle Pass, Tex	774,672	516,638	-33.3	1,254,534	968,566	161.94	187.47
Do	Laredo, Tex	558,782	498,669	-10.8	897,866	934,680	160.68	187.43
Total intrastate		6,230,371	5,759,537	-7.6	7,304,884	7,734,060	117.25	134.28
Total Mexico		9,453,401	7,425,034	-21.5	9,778,009	9,180,273	103.43	123.64
Grand total exports		19,672,752	14,930,712	-24.1	17,751,247	17,133,780	90.23	114.76

[1] In addition, Northern Natural Gas Co. delivered 14,649,017 Mcf of gas produced from the Tiger Ridge area, Mont., to Consolidated Natural Gas Co. (Canada) at a point on the Montana-Saskatchewan border for transportation, and received 14,648,966 Mcf of gas into its line again on the Minnesota-Manitoba border, near Emerson, Manitoba.

Source: Federal Power Commission.

Table 24.—Natural gas imports via pipeline: Volume, value, and unit cost, 1975-76[1]

Importing companies	Point of entry	Gas volume (thousand cubic feet at 14.73 psia and 60° F) 1975	Gas volume 1976	Percent change	Value (dollars) 1975	Value (dollars) 1976	Average price (cents per thousand cubic feet) 1975	Average price 1976
nterstate companies:								
Great Lakes Gas Transmission Co	Noyes, Minn	109,885,018	[2]109,538,833	-0.3	130,543,877	185,585,706	118.80	169.42
Inter-City Minnesota Pipelines Ltd	Warroad, Minn[3]	7,206,073	[4]7,703,760	6.9	8,013,217	10,878,360	111.20	141.21
Michigan-Wisconsin Pipe Line Co	Noyes, Minn	18,250,000	18,300,000	0.3	21,634,077	31,044,877	118.54	169.64
Midwestern Gas Transmission Co	do	118,296,967	119,315,107	0.9	139,970,348	201,584,743	118.32	168.95
Northwest Pipeline Corp	Sumas, Wash	212,166,893	213,243,077	0.5	254,016,231	373,377,191	119.73	175.09
Do	Kingsgate, B. C	50,275,976	47,813,315	-4.9	61,423,853	83,631,482	122.17	174.91
Pacific Gas Transmission Co	Eastport, Idaho	380,232,414	392,463,182	3.2	469,714,574	687,532,867	123.53	175.18
Total interstate		896,313,341	908,377,274	1.3	1,085,316,177	1,573,635,226	121.09	173.24
ntrastate companies:								
The Montana Power Co	Whitlash, Mont	13,441,579	9,890,127	-26.4	14,969,866	16,141,179	111.37	163.20
Do	Babb, Mont	28,738,911	25,743,013	-10.4	35,683,760	45,875,769	124.17	178.21
St. Lawrence Gas Co., Inc	Massena, N.Y	5,496,658	5,536,709	0.7	6,657,943	9,761,142	121.13	176.30
Vermont Gas Systems, Inc	Highgate, Vt	4,124,171	4,065,728	-1.4	4,872,330	6,901,166	118.14	169.74
Total intrastate		51,801,319	45,235,577	-12.7	62,183,899	78,679,256	120.04	173.93
Grand total imports		948,114,660	953,612,851	0.6	1,147,500,076	1,652,314,482	121.03	173.27

[1]All imports of natural gas via pipeline were from Canada.
[2]In addition, 299,827,148 Mcf were received from TransCanada Pipeline Ltd. for transportation, all of which was redelivered to TransCanada at St. Clair and Sault Ste. Marie, Mich.
[3]Imports were also received at International Falls, Minn.
[4]In addition there was a net import of 365,463 Mcf based on 10,968,028 Mcf received from TransCanada Pipeline Ltd. for transportation, and 10,602,565 Mcf redelivered to TransCanada Pipeline, Ltd. at Baudette, Minn.

Table 25.—Liquefied natural gas (LNG)imports, 1976[1]

Volume received:	
42-gallon barrels	2,917,505
Mcf equivalent at 14.73 psia	10,155,340
Average Btu per cubic foot	1,062.7
Value:	
Total dollars	7,856,713
Average price cents per Mcf	77.37

[1]All shipments were from Algeria to the Distrigas Corp. terminal at Everett, Mass.

Source: Federal Power Commission.

Table 26.—Natural gas: World production by country

(Million cubic feet)

Country[1]	1974		1975		1976[p]	
	Gross production[2]	Marketed production[3]	Gross production[2]	Marketed production[3]	Gross production[2]	Marketed production[3]
North America and Caribbean Islands:						
Barbados	[e]90	85	[e]125	120	[e]158	[e]152
Canada	3,497,225	3,045,506	3,506,128	3,089,531	[e]3,563,760	3,067,353
Cuba	[e]930	671	[r] [e]1,220	883	[e]1,220	[e]885
Mexico	744,673	560,911	786,469	583,885	771,785	577,934
Trinidad and Tobago	[r]128,294	[r]68,457	126,490	62,990	137,959	78,559
United States	22,849,793	21,600,522	21,103,530	20,108,661	20,943,778	19,952,438
South America:						
Argentina	332,839	255,748	362,860	271,639	414,592	[e]259,000
Bolivia	144,128	60,539	137,297	60,092	153,952	61,766
Brazil	[r]52,540	17,587	57,371	[r] [e]24,720	57,704	[e]19,330
Chile	[4]248,687	127,503	[4]250,624	120,277	[4]248,332	141,858
Colombia	116,634	65,792	120,754	65,905	117,924	66,715
Ecuador	11,159	[e]1,000	10,559	[e]1,100	10,186	[e]1,100
Peru	69,848	[r]31,809	67,037	[e]35,000	[e]67,000	[e]35,000
Venezuela	1,639,511	475,969	1,342,234	450,295	1,311,392	479,807
Europe:						
Albania[e]	[5]7,170	7,170	[5]7,190	7,190	[5]7,190	7,190
Austria[6]	77,930	73,957	83,305	79,869	75,721	69,093
Belgium[7]	[5]2,246	2,246	[5]1,816	1,816	[5]1,211	1,211
Bulgaria	[5]6,357	6,357	[5]3,906	3,906	[e] [5]3,900	[e]3,900
Czechoslovakia[6]	[5]34,432	34,432	[5]32,807	32,807	[5]33,098	33,098
Denmark[e]	1,034	(8)	1,992	(8)	1,648	(8)
France	392,697	269,414	410,249	259,844	369,319	250,450
Germany, East	[5]273,052	273,052	[5]256,780	256,780	[e] [5]280,000	[e]280,000
Germany, West[6]	734,787	713,202	645,445	639,414	665,537	658,050
Hungary	[5]180,139	[9]180,139	[5]183,000	[9]183,000	[5]214,840	[9]214,840
Italy	[5]540,363	540,363	[5]514,252	514,252	[5]552,336	552,336
Netherlands	2,956,707	2,956,671	[5]3,208,428	3,208,428	[5]3,436,171	3,436,171
Norway[e]	19,700	(8)	106,800	(8)	157,945	(8)
Poland[6]	[5]202,670	202,670	[5]210,580	210,580	[5]236,513	236,513
Romania	[r]1,074,973	1,011,513	1,176,185	1,131,770	[e]1,095,000	1,053,574
Spain	[5]35	35	[5]39	39	[5]41	41
U.S.S.R	[e]9,700,000	9,201,299	[e]10,760,000	10,205,890	[e]11,950,000	11,335,955
United Kingdom[6]	[5]1,230,039	1,230,039	[5]1,273,936	1,273,936	[5]1,316,358	1,316,358
Yugoslavia	[5]51,100	51,100	[5]54,843	54,843	[5]61,094	61,094
Africa:						
Algeria	700,251	198,502	739,874	336,628	863,051	350,778
Angola[e]	37,500	2,400	35,000	2,300	22,000	2,000
Congo (Brazzaville)	23,000	664	14,000	591	[e]13,000	533
Egypt	49,700	[r] [e]1,500	50,600	1,606	72,000	13,432
Gabon	62,507	22,495	60,458	9,252	64,488	5,962
Libya	425,363	[9]345,199	489,035	[9]382,633	[e]620,000	[9]505,527
Morocco	2,841	2,084	2,501	[e]2,000	1,730	[e]1,500
Nigeria	1,017,774	14,255	658,839	16,094	[e]764,000	[e]18,500
Rwanda	[5]35	35	--	--	[5]6	6
Tunisia	[e]7,600	7,098	[r] [e]19,400	7,497	15,891	7,554
Asia:						
Afghanistan	[5]113,006	113,006	105,944	98,881	[e]96,000	89,805
Bahrain	100,010	68,255	101,546	73,343	107,464	76,931
Bangledesh	17,241	17,223	[5]33,000	33,000	[e] [5]35,000	[e]35,000
Brunei	243,811	176,820	268,390	214,394	341,343	298,829
Burma[11]	[e]11,000	[e]4,900	[e]9,700	5,600	8,500	[e]5,400
China, People's Republic of[e]	1,400,000	1,200,000	1,600,000	1,400,000	1,800,000	1,600,000
India	67,733	25,320	81,576	35,244	85,108	53,784

See footnotes at end of table.

Table 26.—Natural gas: World production by country —Continued

(Million cubic feet)

Country[1]	1974		1975		1976[p]	
	Gross production[2]	Marketed production[3]	Gross production[2]	Marketed production[3]	Gross production[2]	Marketed production[3]
Asia: —Continued						
Indonesia	202,423	[e]40,000	222,227	82,224	312,368	126,426
Iran	1,766,721	787,360	1,603,384	771,057	1,776,225	793,739
Iraq	329,237	[9]41,988	368,648	[9]58,410	368,921	[9]58,403
Israel	[5]2,327	2,327	[5]2,105	2,105	[5]2,055	2,055
Japan[6]	102,000	100,540	[e]88,000	86,026	[e]90,000	88,046
Kuwait[12]	466,939	186,894	382,367	183,792	395,775	197,120
Malaysia (Sarawak)[13]	[e]73,000	[r][e]17,000	[r][e]88,000	[r][e]20,000	104,728	22,611
Oman	[r][e]36,000	[e]1,500	[r][e]42,000	[e]1,700	45,000	2,000
Pakistan	[5]175,000	175,000	[5]164,101	164,101	[5]183,635	183,635
Qatar	181,905	[9]45,909	192,005	[9]78,010	167,038	[9]52,124
Saudi Arabia[12]	1,670,729	[e]219,000	1,335,312	[e]200,000	1,667,904	[e]240,000
Syria	[e]40,000	6,356	[e]58,000	7,396	[e]61,000	7,800
Taiwan	56,034	55,372	55,604	54,702	66,638	65,014
Turkey[e]	4,900	2,450	4,600	2,300	5,200	2,600
United Arab Emirates:						
Abu Dhabi	460,995	[9]42,377	432,002	[9]38,493	503,000	[e][9]40,000
Dubai[e]	101,000	19,000	102,000	20,000	127,600	20,000
Sharjah[e]	9,000	([8])	15,000	([8])	15,000	([8])
Oceania:						
Australia	[5]159,339	159,339	[5]177,491	177,491	[5]209,383	209,383
New Zealand	10,647	10,594	[e]11,500	11,442	32,000	30,945
Total	[r]57,449,350	[r]47,178,520	56,418,460	47,517,774	59,300,715	49,459,213

[e]Estimate. [p]Preliminary. [r]Revised. NA Not available.

[1]In addition to the countries listed, Thailand and Zaire produce crude oil and presumably produce natural gas, but available information is inadequate to estimate output levels.

[2]Comprises all marketed production (see footnote 3) plus gas vented, flared, reinjected for reprocessing or for storage, and used to drive gas turbines (without being burned).

[3]Comprises all gas collected and utilized as a fuel or as a chemical industry raw material as well as that used for gas lift in fields, including gas used in oilfields and/or gasfields as a fuel by producers, even though it is not actually sold.

[4]Gas vented or flared is apparently not included; difference between gross production and marketed production is the amount reinjected into reservoirs.

[5]Gross production not reported; marketed output had been reported in lieu of estimating gross output because the quantity vented, flared or reinjected is believed to be small.

[6]Includes output from coal mines as follows in million cubic feet: Austria: 1974—71; 1975—70 (estimate); 1976—NA; Czechoslovakia: 1974—10,806; 1975—10,500 (estimate); 1976—NA; West Germany: 1974—17,940; 1975—16,000 (estimate); 1976—NA; Poland: 1974—7,451; 1975—7,400 (estimate); 1976—NA; the United Kingdom: 1974—3,991; 1975—3,800 (estimate); 1976—NA; Japan: 1974—9,747; 1975—9,500 (estimate); 1976—NA.

[7]Total production obtained from coal mines.

[8]No marketed production reported; there probably was some small field use in Denmark, Norway and Sharjah, and in Norway there was extraction of natural gas liquids in each year 1974-1976, but available information is inadequate to estimate output levels.

[9]Includes gas reinjected to reservoirs, if any.

[10]Excludes gas used for gas lift.

[11]Data are for year ending June 30 of that stated.

[12]Includes 1/2 of production reported for the former Kuwait-Saudi Arabia Neutral Zone.

[13]The Sabah region of Malaysia also reports crude oil production, and thus presumably produces some natural gas, but available information is inadequate to estimate gross output levels, and no data are available to indicate whether or not any part of gross output is classified as marketed.

Natural Gas Liquids

By Thomas G. Clarke[1] and Leonard L. Fanelli[2]

Domestic production of natural gas liquids (NGL) from gas processing plants in 1976 was 587 million barrels, 8.9 million barrels, or 1.5%, less than in 1975. This fourth consecutive annual decline in production was attributed to a decline in the availability of supplies of natural gas and to the decreased liquids content of the gas processed. The volume of natural gas processed during the year totaled 17.72 trillion cubic feet, compared with 17.75 trillion cubic feet in 1975. The total domestic apparent demand for NGL rose to 656.8 million barrels in 1976, after a 3-year decline from the alltime high of 700 million barrels recorded in 1972.

The total value of NGL production increased to $3.28 billion in 1976 from $2.77 billion in 1975. This represented an increase in the average unit value to $5.59 from $4.65 per barrel in 1975. The 1976 increase in value was the result of actions taken under the Government's pricing and allocation program administered by the Federal Energy Administration (FEA). A 1976 amendment to FEA regulations permitted sellers of NGL to pass through increases in product and distribution costs to consumers. In general, the May 15, 1973, selling price was used as a reference base price to which allowable cost increases were added to determine lawful prices. Another change eliminated certain inherent inequities regarding price adjustments by certain classes of sellers.

Presidential Proclamation 4412, issued January 3, 1976, removed all fees on imported NGL products, except for naphtha derived from natural gas. The import rate for naphtha varied from 0.25 cents to 0.5 cents per gallon, depending on the country of origin.

Natural gas liquids are extracted from natural gas at gas processing plants. The lighter products, ethane and liquefied petroleum gases (LPG—butane, propane, pentane, isobutane, and mixed gases) remain in a liquid state only under pressure or when

[1]Mineral specialist, Division of Petroleum and Natural Gas.
[2]Survey statistician, Division of Fuels Data.

Table 1.—Salient statistics of natural gas liquids in the United States

(Thousand barrels, unless otherwise noted)

	1972	1973	1974	1975	1976
Production:					
Ethane	100,691	108,220	117,791	122,945	133,654
LPG	344,045	338,813	330,155	321,141	303,712
Natural gasoline	156,450	155,880	144,129	130,065	129,282
Other[1]	37,030	31,510	24,023	21,807	20,397
Total production	638,216	634,423	616,098	595,958	587,045
Imports	63,829	r87,346	77,335	67,699	71,844
Exports	11,469	r9,955	r9,038	r9,488	8,993
Apparent domestic demand	700,351	r697,117	r669,040	r644,186	656,845
Average value at plant (dollars per barrel)	2.28	2.93	5.01	4.65	5.59
All stocks at plants, terminals and refineries	84,243	98,940	114,295	[2]124,278	[3]117,329

rRevised.
[1]Includes isopentane, plant condensate, finished gasoline, special naphtha, distillate fuel oil, kerosine, and miscellaneous.
[2]Includes 93,595,000 barrels in underground storage.
[3]Includes 81,768,000 barrels in underground storage.

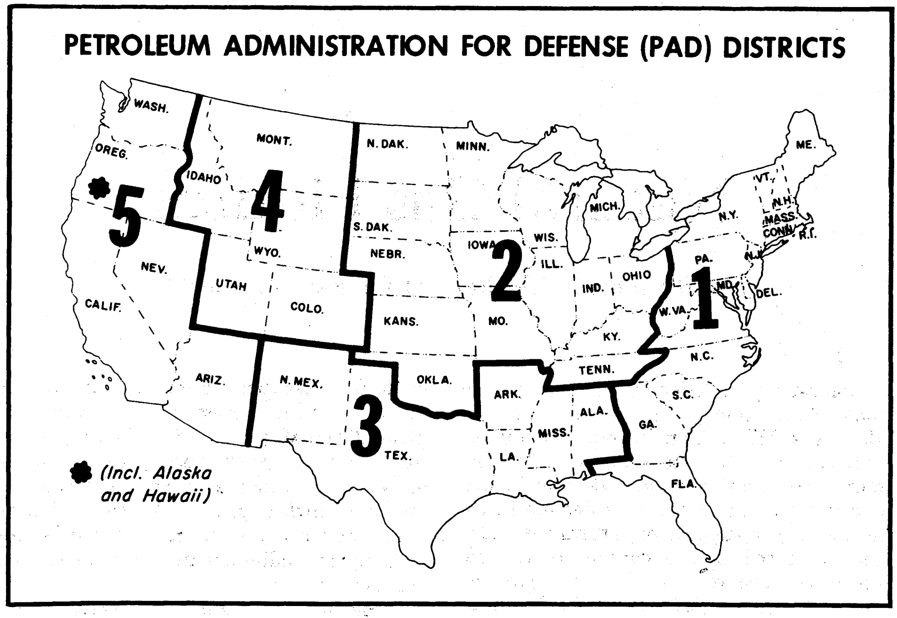

Figure 1.—Map of PAD districts.

cooled. Natural gasoline and plant condensate remain liquid at atmospheric pressure and may be run to fractionators for the production of naphtha, jet fuel, kerosine, distillate fuel oil, and other finished products.

Data presented in this chapter were compiled from reports of natural gasoline plants, cycling plants, and fractionators that process natural gas. Plant condensate is included with NGL; field condensate is included with crude oil data presented in the petroleum chapter. Ethane and liquefied gases recovered from crude oil refinery operations (such as ethane, butane, and propane) are classified as liquefied refinery gases (LRG) and are reported as refined petroleum products.

DOMESTIC PRODUCTION

Production of NGL at natural gas processing plants decreased to 587 million barrels in 1976, 8.9 million barrels less than in 1975. The output of ethane continued to increase for the eighth consecutive year, but production decreased in other NGL product categories. The rise in ethane production to about 23% of total NGL output was commensurate with increasing demand for ethane as a petrochemical feedstock, and improved NGL plant thermodynamic efficiency. LPG comprised 52% of total 1976 NGL production, while natural gasoline, condensate, and other products accounted for the remaining 25% of production. A tabulation indicating quantities and percentage change in production of the various NGL product categories between 1975 and 1976 follows:

	Thousand barrels	Percent
Ethane	+10,709	+8.70
LPG:		
Propane	-10,959	-5.46
Other	-6,470	-5.37
Natural gasoline and isopentane	-1,072	-0.08
Other natural gas liquids	-1,121	-6.21
Total	-8,913	-1.5

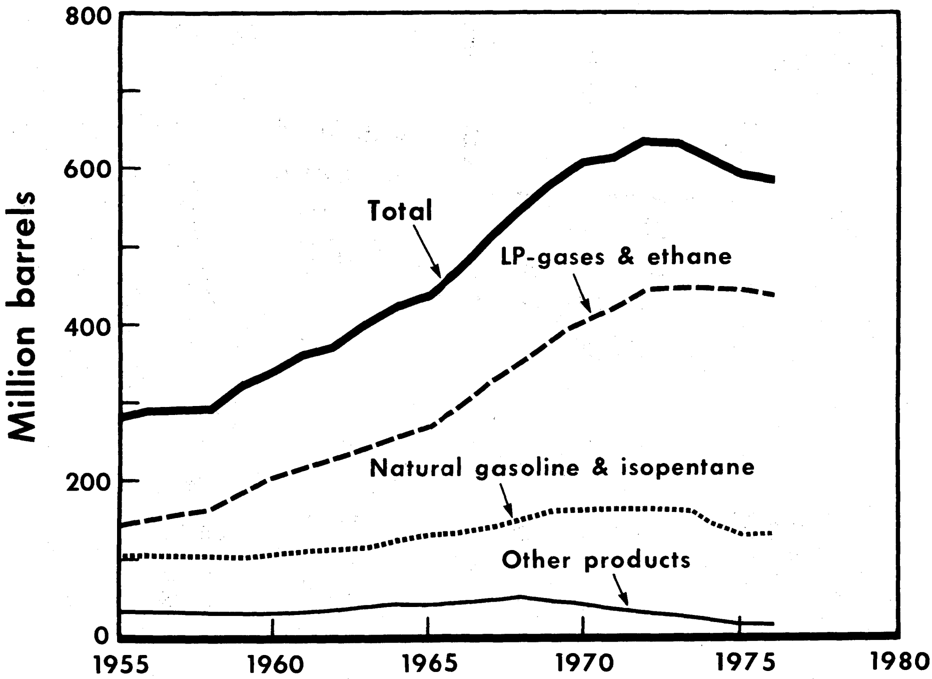

Figure 2.—Production of natural gas liquids in the United States.

At yearend 1976, the number of gas processing plants in operation totaled 763, compared with 754 a year earlier.[3] Plants were located in 23 States and were owned and/or operated by about 130 companies. Production from gas processing plants was accounted for by Texas, 46%; Louisiana, 14%; Oklahoma, 11%; California, 5%; New Mexico and Wyoming, 4.5% each; and others, 15%. Gas processing plant capacity remained almost constant at 72,610 million cubic feet (MMcf) per day, a decline of only 0.1% from that of 1975. During 1976 the gas throughput nearly maintained the level of 1975, declining only 0.4%, from 48,626 MMcf per day to 48,410 MMcf per day.

RESERVES

The American Gas Association Committee on Natural Gas Reserves estimated proved recoverable reserves of NGL in the United States on December 31, 1976, were 6,402 million barrels, an increase of 134.1 million barrels from that of 1975. This increase ended 8 consecutive years of decreasing reserves. New field and reservoir

[3]Oil and Gas Journal. V. 77, No. 28, July 11, 1977, p. 74.

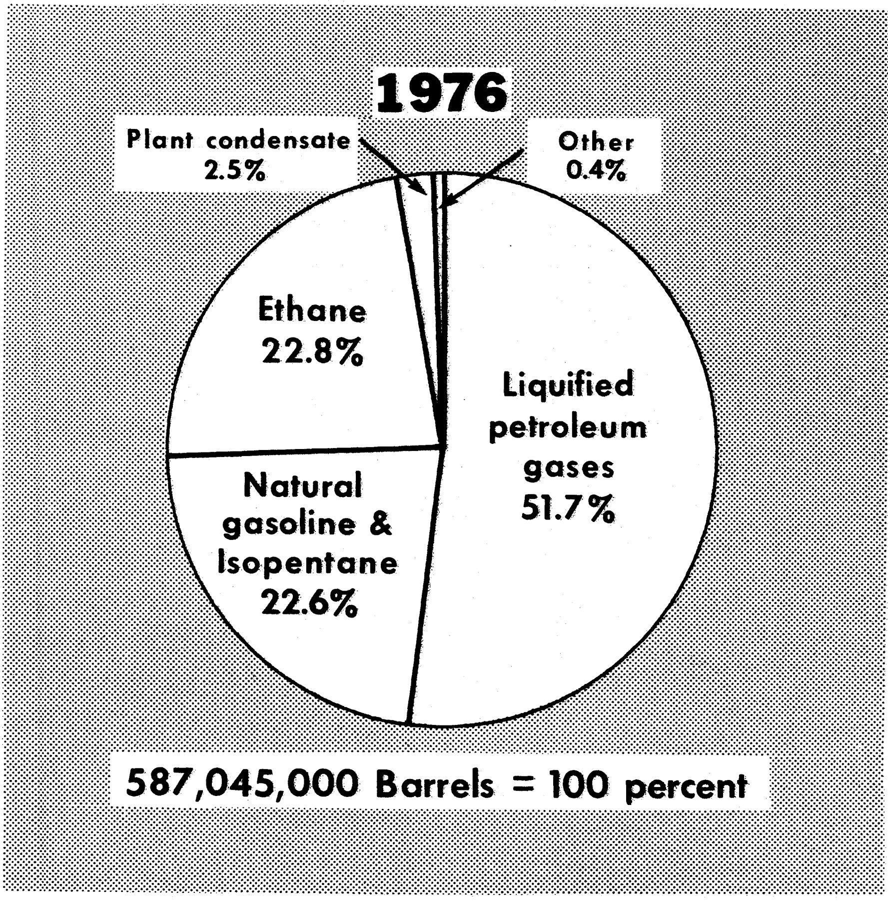

Figure 3.—Relative production of natural gas liquids components, 1976.

discoveries amounted to 61.8 million barrels, principally in Texas and Louisiana. Extensions and net revisions were 772.9 million barrels; Alaska accounted for almost 408 million barrels, the most significant addition to reserves during the year. Of total reserves at yearend 1976, Texas accounted for 39% and Louisiana accounted for 25%.

CONSUMPTION AND USES

Approximately 45% of all 1976 NGL plant output was utilized by refineries for fuel or petrochemical uses. Refinery input of natural gas products during 1976 was 265.45 million barrels, an increase of 2.4% from the 1975 level. Increases were accounted for by butane, propane, butane–propane mixtures, and plant condensate, but the input of natural gasoline declined in conjunction with the reduced domestic output of that product. The following summary shows NGL product input to refineries, in thousand barrels:

Product	1975	1976	Change (percent)
Propane	3,926	4,510	+14.9
Butane:			
Isobutane	35,760	32,200	-10.0
Normal butane	35,056	42,179	+20.3
Other butane	13,647	14,482	+6.1
Total butane	84,463	88,861	+5.2
Butane-propane mixtures	1,273	1,889	+48.4
Natural gasoline	134,087	132,320	-1.3
Isopentane	--	--	--
Plant condensate	35,570	37,871	+6.5
Grand total	259,319	265,451	+2.4

Total domestic demand for liquefied gases and ethane at gas processing plants and refineries in 1976, as indicated in table 11, was 513.97 million barrels, up about 5.7% from a demand of 486.45 million barrels in 1975. NGL processing plants supplied 388.2 million barrels, or 76% of total demand; the remainder was LRG used in petrochemical manufacture, 8%, and for fuel at refineries, 16%.

The highest domestic demand was for propane (including propylene) which accounted for 303.84 million barrels, or 59% of the total. Ethane (including ethylene) demand was 132.71 million barrels, about 26% of the total. All of the ethane was utilized for the production of petrochemicals, primarily ethylene. According to the U.S. International Trade Commission, total production of ethylene from ethane was 22 billion pounds in 1976, up almost 6% from the 20.5 billion pounds produced in 1975.

Sales of ethane and LPG in 1976 were 26.0 billion gallons, an increase of 1.4 billion gallons from the 1975 output. Propane accounted for 51.7% of the sales and ethane was 21.5%. The chemical industry was the largest user, accounting for 37.2% of total sales. Residential and commercial use was 28.2% of sales, and 15.4% was used in gasoline production.

STOCKS

Yearend stocks of NGL and ethane at plants, terminals, and refineries were 117.33 million barrels compared with 124.28 million barrels in 1975. Included in the 1976 total were 81.77 million barrels in underground storage. The decrease in stocks reflected cooler than normal temperatures during the fall and early winter, especially in the eastern half of the United States. Total stocks at plants and terminals were down 5.96 million barrels to 112.26 million barrels, and refinery stocks fell 0.99 million barrels to 5.07 million barrels. Ethane stocks at plants and terminals increased 6.6 million barrels during 1976, and natural gasoline stocks were up 0.1 million barrels. However, propane stocks at plants and terminals declined 6.6 million barrels; butane, 5.3 million barrels; and condensate, 0.2 million barrels.

PRICES AND VALUE

The average unit value of NGL production at natural gas processing plants was $5.59 in 1976, an increase of 20% from 1975. Total value of NGL was $3.28 billion in 1976, compared with $2.77 billion in 1975. LPG and ethane accounted for about 70% of total NGL value in 1976. A tabulation of average values, from 1972-76, in dollars per barrel, follows:

	1972	1973	1974	1975	1976
LPG and ethane	1.91	2.66	4.42	4.26	5.26
Natural gasoline and isopentane	3.06	3.51	6.59	5.81	6.65
Plant condensate	3.39	3.94	6.52	5.47	5.69
Finished gasoline and naphtha	4.66	4.29	7.97	7.76	9.99
Other[1]	2.58	3.25	5.39	5.35	7.52
Total (average)	2.28	2.93	5.01	4.65	5.59

[1]Includes kerosine, distillate fuel oil, and miscellaneous products.

Natural gas liquids continued to be subject to FEA mandatory allocation and price controls, and the rise in prices in 1976 was due primarily to a passthrough of product and distribution costs permitted by FEA. Propane price data for six widely separated domestic areas are presented in table 17.

FOREIGN TRADE

Net imports of NGL increased 8% to 62.9 million barrels in 1976 from 58.2 million barrels in 1975. Gross imports, consisting of LPG and plant condensate, increased 6% from 67.7 million barrels in 1975 to 71.8 million barrels in 1976. Imports of LPG increased 16%, but receipts of plant condensate declined 9.5%. The increase in LPG imports was associated with the declining availability of domestic natural gas supply for NGL plants and colder than normal temperatures in the fall and early winter, especially in the eastern half of the country. The decrease in imports of plant condensate resulted from a shift to a higher proportion of lighter fractions, especially propane, in the feedstocks shipped from Canada to synthetic natural gas plants in Michigan and Ohio.

Canada supplied 74% of LPG imports and 99% of plant condensate receipts in 1976. Venezuela was the source of 12% of LPG imports and the remaining plant condensate. Countries supplying more than 100,000 barrels of LPG imports in 1976 were Algeria, Australia, France, the Hawaiian Trade Zone, Kuwait, Saudi Arabia, and the United Kingdom.

Exports of NGL decreased 5% to 9.0 million barrels in 1976, compared with 9.5 million barrels in 1975. Small quantities of NGL were shipped to numerous countries, but 99% of the exports of NGL went to Mexico and Canada. Mexico, traditionally the largest recipient of U.S. LPG exports, received 97% of the total volume, comprised mainly of butane-propane mixtures, and 2% of the exports were dispatched to Canadian consumers. Total NGL exports consisted of butane, 2.8%; propane, 23.6%; and butane-propane mixtures, 73.6%.

WORLD REVIEW

In 1976 the United States and Canada continued as the world's largest producers of NGL, with a combined total of 692 million barrels, about 66% of total world production. Of growing importance in the world export trade was the increased production from the Middle Eastern area, mainly Iran, Kuwait, and Saudi Arabia, which produced a combined estimated total of 99.6 million barrels in 1976, compared with 80.1 million barrels in 1975.

The Government of Saudi Arabia and the Arabian American Oil Co. (Aramco) completed the first phase of construction of several NGL processing centers, including a compression center at Abqaiq and a treatment and a fractionation plant at Ra's at Tannurah, Saudi Arabia's main export terminal. The Abqaiq plant was designed with a gas processing capacity of 320 MMcf per day from gas-oil separator plants in the Ghawar and Abqaiq fields. Production of 140,000 barrels per day (bpd) of NGL will be piped to Ra's at Tannurah for export. The second phase of the $1 billion Aramco expansion will be at Berri-Al Jubayl several miles north of the Ra's at Tannurah terminal. Production capacity will be 600 MMcf per day with an NGL recovery of 70,000 bpd, a smaller yield than at Abqaiq because of the lower NGL content of Berri-Al Jubayl gas.

Northern Natural Gas Co. and Shell International Gas, Ltd. negotiated a contract valued at $1 billion for the sale of LPG to be produced from the North Sea over a 10-year period. This may be the first long-term LPG contract negotiated around future price indices: The periodic adjustments are to be based upon the prices of Arabian light crude, the U.S. Wholesale Price Index, and the U.N. Index for Exports of Manufactured Goods from Industrial Countries. Deliveries are scheduled to start after January 1, 1979, to one of five U.S. east or gulf coast ports. About 3 million barrels of LPG are to be delivered during the first year, 7 million barrels during the second, and 7.9 million barrels annually for the remainder of the contract period. The LPG would be produced from the Shell United Kingdom, Ltd. share of the Brent and other British North Sea fields. Construction of an extraction plant in Peterhead, Scotland, is planned for the gas processing.

The world's first open sea offshore NGL plant was completed and went onstream at midyear in the Ardjuna field area of the Java Sea, northeast of Jakarta, Indonesia. The Ardjuna field is operated by the Atlantic Richfield Co. under a production agreement with Pertamina, the Indonesian State-owned petroleum agency.

Pemex, the Mexican Government-owned petroleum agency, continued construction in 1976 on a large gas processing plant complex at Tabasco, in southern Mexico. When completed in 1978, it will have a throughput capacity of 2 billion cubic feet of gas per day. A sour gas feedstock will be processed for maximum ethane and other liquids by a turboexpansion process. Three gas-sweetening facilities were put onstream during the year, each with a rated throughput capacity of 400 MMcf of gas per day. The desulfurized sweet gas from these facilities is processed through two 500-MMcf-per-day turboexpanders for NGL extraction.

A subsidiary of the Fluor Corp. was granted a contract for the design, engineering, and construction of two identical NGL processing centers in Iran. The total project will be valued at $300 million, and each plant will be capable of processing 1.5 billion cubic feet of gas per day when completed in 1977. Gas from the Pazanam Dome field, located near Agha Jari in Southern Iran, will be utilized in the new processing centers. The residue gas from each of these centers will be reinjected into separate oilfields located nearby.

Combustion Engineering, Inc. and Mitsubishi Heavy Industries, Ltd. of Japan are to construct 13 offshore platforms in the Arabian Gulf for the Qatar Gas Co., Ltd. The platforms, for the $170 million NGL gathering project, will be located in the Idd el Shargi, Maydan-Mahzan, and Bul Hanine field areas, in offshore Qatar. Living quarters and production modules, including separation, compressor, cooling, and dehydration equipment, will be installed in each field. Completion of the project was scheduled for mid-1979.

The Kuwait Oil Co. recently awarded a contract to Kellogg International Corp. for the construction of gas-gathering system facilities. Associated gas will be collected from 25 gathering centers located in the main field areas of Kuwait, and the gases and field condensates will be transported to Mina al Ahmadi, a port on the Persian Gulf, for final processing in a LPG plant. The output of liquids will be at a daily design capacity of 100,000 barrels of propane, 55,000 barrels of butane, and 41,000 barrels of natural gasoline. Completion of the facilities was scheduled for 1978.

Work continued on a large NGL processing center for sour gas and condensate in the Orenburg gasfield on the Ural River in south-central U.S.S.R. Reportedly, the second of 10 plants planned for the complex was onstream at the beginning of 1976. The extraction process separates the sour gas and condensate, dehydrates the sour gas, and prepares it for final low-temperature separation of the NGL. Each plant will have extraction units capable of a throughput of 840 MMcf of gas per day.

TECHNOLOGY

During 1976, Halliburton Resource Management, Inc. began operating a newly designed, low temperature NGL field recovery unit which extracts LPG and condensate from natural gas feedstocks at rates substantially larger than conventional plants. The unit operates most efficiently at low pressures, by utilizing a vortex tube, that delivers more refrigeration with less pressure drop than a unit using a choke. Recovery rates from a gas stream are thus more efficient than from a conventional field processing unit.

Elf Aquitane of France, announced a new hydrocracking process for the production of propane from butane feedstocks that utilizes a zealite catalyst which reacts with butane to induce hydrogenation. The propane yield is about 90% of the butane feedstock, and the production of paraffins, methane, and ethane byproducts is also minimized by use of this process.

Table 2.—Plant production, stocks at plants and terminals and shipments from plants of natural gas processing plant products in 1976

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total 1976	Total 1975
Ethane:														
Production	10,934	10,662	11,203	10,728	10,939	10,476	11,026	11,054	11,209	11,520	11,803	12,100	133,654	122,945
Stocks	7,483	8,579	8,669	9,192	9,428	9,853	10,663	11,160	11,594	11,855	12,770	13,600	13,600	7,014
Shipments	10,465	9,566	11,113	10,205	10,703	10,051	10,216	10,557	10,775	11,259	10,888	11,270	127,068	120,493
Liquefied petroleum gases:														
Production	26,288	25,306	26,370	24,989	25,495	24,455	25,092	24,760	24,297	25,671	25,305	25,684	303,712	321,141
Stocks	90,579	86,341	90,056	94,808	101,525	108,607	114,921	118,793	121,653	119,386	109,827	93,117	93,117	105,557
Shipments	41,266	29,544	22,655	20,237	18,778	17,373	18,778	20,888	21,437	27,938	34,864	42,394	316,152	313,540
Isopentane:														
Production	316	292	305	283	287	291	284	288	275	286	295	268	3,470	3,759
Stocks	5	6	6	7	7	8	7	9	7	7	9	5	5	6
Shipmetns	317	291	305	282	287	290	285	286	277	286	293	272	3,471	3,769
Natural gasoline:														
Production	10,037	9,848	10,642	11,057	11,092	11,509	11,479	11,983	10,948	10,813	10,060	9,814	129,282	130,065
Stocks	5,068	5,193	5,368	5,301	5,526	5,491	5,553	5,765	5,872	5,480	5,493	5,026	5,026	4,897
Shipments	9,866	9,723	10,467	11,124	10,867	11,544	11,417	11,771	10,841	11,205	10,047	10,281	129,153	130,370
Plant condensate:														
Production	1,343	1,254	1,337	1,237	1,203	1,246	1,286	1,221	1,186	1,188	997	1,202	14,700	15,626
Stocks	454	473	493	553	466	483	447	505	428	404	483	413	413	617
Shipments	1,506	1,235	1,317	1,177	1,290	1,229	1,322	1,163	1,263	1,212	918	1,272	14,904	15,516
Motor gasoline:														
Production	77	76	80	74	77	83	82	78	75	80	83	81	946	959
Stocks	46	47	48	43	42	43	39	36	42	55	45	45	45	53
Shipments	84	75	79	79	78	82	86	81	69	67	93	81	954	970
Special naphthas:														
Production	7	7	6	--	--	--	--	--	--	--	--	--	20	125
Stocks	2	1	--	--	--	--	--	--	--	--	--	--	--	4
Shipments	9	8	7	--	--	--	--	--	--	--	--	--	24	125
Kerosine:														
Production	16	13	16	16	14	8	11	10	16	6	12	11	149	178
Stocks	15	13	8	9	8	8	9	8	8	8	8	7	7	15
Shipments	16	15	21	15	15	8	10	11	16	6	12	12	157	180
Distillate:														
Production	16	14	18	14	15	17	17	14	12	13	13	14	177	214
Stocks	49	33	34	36	40	46	39	39	38	39	37	38	38	46
Shipments	13	30	17	12	11	11	24	14	13	12	15	13	185	207
Miscellaneous products:														
Production	103	101	95	83	96	81	63	74	53	44	50	92	935	946
Stocks	6	4	5	6	6	5	6	6	5	5	5	5	5	5
Shipments	102	103	94	82	96	82	62	74	54	44	50	92	935	951
All products total:														
Production	49,137	47,573	50,072	48,481	49,218	48,166	49,340	49,482	48,071	49,621	48,618	49,266	587,045	595,958
Stocks	103,707	100,690	104,687	109,955	117,048	124,544	131,684	136,321	139,647	137,239	128,677	112,256	112,256	118,214
Shipments	63,644	50,590	46,075	43,213	42,125	40,670	42,200	44,845	44,745	52,029	57,180	65,687	593,003	586,121

Table 3.—Total production of products at natural gas processing plants, by State and month, 1976

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Arkansas	46	43	45	44	39	50	58	56	55	58	58	59	611
California	744	706	768	734	756	728	747	748	707	733	704	702	8,777
Colorado	662	644	692	672	669	651	646	648	614	758	844	909	8,409
Florida, Pennsylvania, West Virginia	1,244	1,238	1,362	1,340	1,148	1,253	1,286	1,390	1,283	1,398	1,353	1,349	15,644
Illinois and Kentucky	849	935	1,006	978	1,020	942	1,004	938	900	995	938	1,051	11,556
Kansas	2,553	2,356	2,604	2,401	2,133	2,162	2,453	2,596	2,391	2,704	2,786	3,062	30,201
Louisiana	10,877	10,394	10,662	9,915	10,426	9,465	9,605	9,299	9,272	9,500	9,497	9,867	118,779
Michigan	142	127	146	144	164	572	627	610	574	475	534	604	4,719
Mississippi and Alabama	49	58	69	60	76	72	73	73	75	86	79	75	845
Montana, Utah, Alaska	316	310	326	306	305	310	397	396	379	410	381	394	4,230
Nebraska, North Dakota, South Dakota	142	141	142	139	148	154	157	158	154	160	151	153	1,799
New Mexico	3,356	3,330	3,631	3,516	3,580	3,520	3,524	3,608	3,411	3,591	3,508	3,569	42,144
Oklahoma	3,390	3,298	3,705	3,626	3,550	3,325	3,489	3,429	3,522	3,783	3,664	3,733	42,514
Texas	23,974	23,272	24,136	23,864	24,441	24,189	24,424	24,689	23,896	24,082	23,252	22,873	287,092
Wyoming	793	721	778	742	763	773	850	844	838	888	869	866	9,725
Total United States	49,137	47,573	50,072	48,481	49,218	48,166	49,340	49,482	48,071	49,621	48,618	49,266	587,045

Table 4.—Production of natural gas liquids at natural gas processing plants, and natural gas processed in the United States by State, in 1975-76

(Million cubic feet at 14.73 psia at 60° F unless otherwise stated)

State	Total natural gas liquids and ethane production (thousand barrels)	Natural gas processed
1975:		
Arkansas	603	17,918
California	9,328	213,079
Colorado	6,563	136,090
Florida, Pennsylvania, West Virginia	12,977	765,597
Illinois and Kentucky	12,047	322,393
Kansas	29,858	1,367,949
Louisiana	135,522	5,831,487
Michigan	2,004	79,154
Mississippi and Alabama	875	29,694
Montana, Utah, Alaska	3,948	156,203
Nebraska, North Dakota, South Dakota	1,910	34,463
New Mexico	39,408	1,037,160
Oklahoma	40,475	1,033,003
Texas	291,470	6,509,132
Wyoming	8,970	215,104
Total	595,958	17,748,426
1976:		
Arkansas	611	20,370
California	8,777	216,667
Colorado	8,409	175,624
Florida, Pennsylvania, West Virginia	15,644	854,064
Illinois and Kentucky	11,556	305,441
Kansas	30,201	1,389,850
Louisiana	118,779	5,749,783
Michigan	4,719	151,318
Mississippi and Alabama	845	25,517
Montana, Utah, Alaska	4,230	149,865
Nebraska, North Dakota, South Dakota	1,799	35,351
New Mexico	42,144	1,066,104
Oklahoma	42,514	1,072,992
Texas	287,092	6,253,159
Wyoming	9,725	251,846
Total	587,045	17,717,951

Table 5.—Natural gas liquids production and value at natural gas processing plants, by State and product, in 1976

State	LPG and ethane: Quantity (thousand barrels)	LPG and ethane: Value (thousand dollars)	LPG and ethane: Dollars per barrel[1]	Natural gasoline and isopentane: Quantity (thousand barrels)	Natural gasoline and isopentane: Value (thousand dollars)	Natural gasoline and isopentane: Dollars per barrel[1]	Plant condensate: Quantity (thousand barrels)	Plant condensate: Value (thousand dollars)	Plant condensate: Dollars per barrel[1]
Arkansas	408	$2,440	$5.98	177	$1,271	$7.18	10	$71	$7.09
California	4,151	25,487	6.14	4,188	29,023	6.93	438	2,632	6.01
Colorado	6,505	38,249	5.88	1,895	13,322	7.03	9	81	8.97
Florida, Pennsylvania, West Virginia	13,848	69,141	4.99	1,796	11,195	6.23	--	--	--
Illinois and Kentucky	11,015	53,906	4.89	536	3,087	5.76	5	18	3.53
Kansas	23,767	83,422	3.51	6,430	30,993	4.82	4	24	5.92
Louisiana	91,701	375,057	4.09	23,866	131,502	5.51	2,866	17,998	6.28
Michigan	1,215	6,306	5.19	3,497	19,688	5.63	--	--	--
Mississippi and Alabama	549	3,577	6.52	293	1,931	6.59	--	--	--
Montana, Utah, Alaska	2,361	13,238	5.61	1,868	10,860	5.81	1	6	5.92
Nebraska, North Dakota, South Dakota	1,377	8,406	6.10	421	2,937	6.98	1	5	5.35
New Mexico	32,654	180,577	5.53	9,413	50,924	5.41	41	262	6.39
Oklahoma	31,620	179,602	5.68	10,180	69,326	6.81	597	4,376	7.33
Texas	209,514	1,223,562	5.84	65,338	487,794	7.46	10,538	57,116	5.42
Wyoming	6,681	35,677	5.34	2,854	18,865	6.61	190	1,001	5.27
Total	437,366	2,298,647	5.26	132,752	882,718	6.65	14,700	83,590	5.69

State	Finished gasoline and naphtha: Quantity (thousand barrels)	Finished gasoline and naphtha: Value (thousand dollars)	Finished gasoline and naphtha: Dollars per barrel[1]	Other products[2]: Quantity (thousand barrels)	Other products[2]: Value (thousand dollars)	Other products[2]: Dollars per barrel[1]	Total: Quantity (thousand barrels)	Total: Value (thousand dollars)	Total: Dollars per barrel[1]
Arkansas	--	--	--	16	80	5.00	611	3,862	6.32
California	--	--	--	--	--	--	8,777	57,142	6.51
Colorado	--	--	--	--	--	--	8,409	51,652	6.14
Florida, Pennsylvania, West Virginia	--	--	--	--	--	--	15,644	80,336	5.14
Illinois and Kentucky	--	--	--	--	--	--	11,556	57,011	4.93
Kansas	--	--	--	--	--	--	30,201	114,439	3.79
Louisiana	133	1,037	7.80	213	1,146	5.38	118,779	526,740	4.43
Michigan	--	--	--	7	37	5.22	4,719	26,031	5.52
Mississippi and Alabama	--	--	--	3	16	5.34	845	5,524	6.54
Montana, Utah, Alaska	--	--	--	--	--	--	4,230	24,104	5.70
Nebraska, North Dakota, South Dakota	--	--	--	--	--	--	1,799	11,348	6.31
New Mexico	--	--	--	36	183	5.08	42,144	231,946	5.50

See footnotes at end of table.

Table 5.—Natural gas liquids production and value at natural gas processing plants, by State and product, in 1976 —Continued

State	Finished gasoline and naphtha			Other products[2]			Total		
	Quantity (thousand barrels)	Value (thousand dollars)	Dollars per barrel[1]	Quantity (thousand barrels)	Value (thousand dollars)	Dollars per barrel[1]	Quantity (thousand barrels)	Value (thousand dollars)	Dollars per barrel[1]
Oklahoma	--	--	--	117	$714	$6.10	42,514	$254,018	$5.97
Texas	833	$8,613	$10.34	869	7,308	8.41	287,092	1,784,393	6.22
Wyoming	--	--	--	--	--	--	9,725	55,543	5.71
Total	966	9,650	9.99	1,261	9,484	7.52	587,045	3,284,089	5.59

[1]Represents average unit value of sales throughout the year.
[2]Includes kerosine, distillate fuel oil, and miscellaneous products.

Source: Company reports and Bureau of Mines estimates.

Table 6.—Production of natural gas liquids and ethane at natural gas processing plants in the United States, in 1976

(Thousand barrels)

PAD districts and States	Ethane	Liquefied petroleum gases: Propane	Normal butane	Other butanes	Butane-propane mixtures	Iso-butane	Total	Natural gasoline and isopentane	Plant condensate	Finished gasoline and naphtha	All other products[1]	Total
District I	5,176	5,932	1,972	483	--	285	8,672	1,796	--	--	--	15,644
District II:												
Michigan	--	536	215	--	218	246	1,215	3,497	--	--	7	4,719
Kansas	3,682	13,794	4,196	506	4	1,585	20,085	6,430	4	--	--	30,201
Oklahoma	6,530	16,690	4,594	1,980	21	1,805	25,090	10,180	597	--	117	42,514
Other States[2]	6,456	3,835	1,622	--	--	479	5,936	957	6	--	--	13,355
Total District II	16,668	34,855	10,627	2,486	243	4,115	52,326	21,064	607	--	124	90,789
District III:												
Alabama and Mississippi	--	257	157	66	69	--	549	293	--	--	3	845
Arkansas	--	225	145	--	--	38	408	177	10	--	16	611
Louisiana:												
Gulf	33,433	32,823	10,355	458	22	9,481	53,139	22,794	2,338	--	155	111,859
Inland	1,074	2,124	1,090	31	86	724	4,055	1,072	528	133	58	6,920
Total Louisiana	34,507	34,947	11,445	489	108	10,205	57,194	23,866	2,866	133	213	118,779
New Mexico	7,289	14,785	4,356	3,974	97	2,153	25,365	9,413	41	--	36	42,144
Texas:												
Gulf	17,654	14,705	5,276	338	377	4,313	25,009	11,316	938	106	97	55,120
West	49,829	72,595	18,890	15,956	1,270	8,311	117,022	54,022	9,600	727	772	231,972
Total Texas	67,483	87,300	24,166	16,294	1,647	12,624	142,031	65,338	10,538	833	869	287,092
Total District III	109,279	137,514	40,269	20,823	1,921	25,020	225,547	99,087	13,455	966	1,137	449,471
District IV:												
Colorado	2,005	2,811	56	1,610	--	23	4,500	1,895	9	--	--	8,409
Montana, Utah, Alaska	--	1,558	665	49	--	89	2,361	1,868	1	--	--	4,230
Wyoming	526	4,081	1,300	570	--	204	6,155	2,854	190	--	--	9,725
Total District IV	2,531	8,450	2,021	2,229	--	316	13,016	6,617	200	--	--	22,364
District V	--	2,863	421	39	393	435	4,151	4,188	438	--	--	8,777
Total United States	133,654	189,614	55,310	26,060	2,557	30,171	303,712	132,752	14,700	966	1,261	587,045

[1]Includes jet fuel, kerosine, distillate, and other.
[2]Other States includes Illinois, Kentucky, Nebraska, North Dakota, and South Dakota.

Table 7.—Production of natural gasoline by vapor pressure and PAD district in the United States, in 1976

(Thousand barrels)

Reid vapor pressure	District I	District II	District III	District IV	District V	Total
12 pounds and less	351	6,193	58,471	1,924	327	67,266
Over 12 pounds including 14 pounds	507	5,755	18,632	1,882	342	27,118
Over 14 pounds including 18 pounds	6	2,302	5,583	361	248	8,500
Over 18 pounds including 22 pounds	10	300	1,148	24	635	2,117
Over 22 pounds including 26 pounds	77	2,602	6,585	441	645	10,350
Over 26 pounds	845	3,159	6,092	1,164	2,671	13,931
Total	1,796	20,311	96,511	5,796	4,868	129,282

Table 8.—Comparison of 1975 and 1976 natural gas liquids production and value

	Thousand barrels		Per-cent change	Thousand dollars		Per-cent change	Dollars per barrel		Per-cent change
	1975	1976		1975	1976		1975	1976	
LPG and ethane	444,086	437,366	-1.5	1,893,890	2,298,647	+21.4	4.26	5.26	+23.5
Natural gasoline and isopentane	133,824	132,752	-0.8	777,637	882,718	+13.5	5.81	6.65	+14.5
Plant condensate	15,626	14,700	-5.9	85,492	83,590	-2.2	5.47	5.69	+4.0
Finshed gasoline and naphtha	1,084	966	-10.9	8,411	9,650	+14.7	7.76	9.99	+28.7
Other products	1,338	1,261	-5.8	7,158	9,484	+32.5	5.35	7.52	+40.6
Total or average	595,958	587,045	-1.5	2,772,588	3,284,089	+18.4	4.65	5.59	+20.2

Table 9.—Estimated proved recoverable reserves of natural gas liquids in the United States, by State

(Thousand barrels)

State	Reserves as of Dec. 31, 1975	Changes in reserves				Reserves as of Dec. 31, 1976		
		Extensions	Revisions	New field discoveries	New reservoir discoveries	Total natural gas liquids[1]	Nonassociated	Associated dissolved
Alabama	251,348	-35,930	31,435	--	--	241,144	237,012	4,132
Alaska	2,521	407,970	--	--	--	409,718	--	409,718
Arkansas	3,852	4,458	--	--	--	7,279	3,520	3,759
California[2]	107,502	1,651	3,886	--	85	104,395	2,118	102,277
Colorado	61,749	14,730	1,330	--	--	68,956	50,787	18,169
Florida	45,682	-1,522	--	--	--	37,422	--	37,422
Kansas	417,029	-10,081	7,349	493	98	388,078	378,902	9,176
Kentucky	42,681	-92	1,525	45	46	41,132	41,132	--
Louisiana[2] [3]	1,717,700	61,728	21,464	3,636	22,800	1,622,834	1,359,678	263,156
Michigan	20,633	3,252	--	848	--	22,397	5,081	17,316
Mississippi	15,170	-1,732	1,248	603	18	13,771	9,118	4,653
Montana	3,318	2,000	--	--	--	4,697	2,966	1,731
Nebraska	821	--	--	--	--	627	238	389
New Mexico	368,563	56,237	7,826	91	57	394,098	292,781	101,317
North Dakota	50,011	900	--	--	--	49,090	--	49,090
Oklahoma	299,155	-2,893	19,218	3,467	474	279,795	177,645	102,150
Pennsylvania	515	--	--	--	--	446	446	--
Texas[2]	2,660,668	113,477	55,053	11,026	17,682	2,527,837	1,178,612	1,349,225
Utah	49,367	-2,872	--	--	--	42,488	486	42,002
West Virginia	82,463	--	6,444	151	118	83,833	83,833	--
Wyoming	67,082	3,075	1,794	100	--	61,930	33,373	28,557
Total United States	6,267,830	614,356	158,572	20,460	41,378	6,401,967	3,857,728	2,544,239
Gulf of Mexico[4]	811,344	80,926	15,127	4,079	17,681	852,954	758,659	94,295

[1]American Gas Association data based on preliminary net production.
[2]Includes offshore.
[3]Reported quantities include reserves estimated from same reservoirs considered natural gas bearing based on electrical logs, core data, and other available engineering and geological data.
[4]Included with Louisiana and Texas.

Source: American Gas Association.

Table 10.—Natural gas liquids[1] used as refinery input in the United States, by Bureau of Mines refinery district and by month, in 1976

(Thousand barrels)

District	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
East coast	--	--	21	--	--	--	--	--	--	--	--	--	21
Appalachian	471	448	376	360	381	356	354	302	250	367	137	250	4,052
Indiana, Illinois, Kentucky, etc.	3,013	3,861	3,419	2,175	2,420	3,007	2,658	2,839	2,509	2,896	3,562	4,032	36,391
Minnesota, Wisconsin, North Dakota, South Dakota	457	408	538	654	601	516	466	384	443	525	627	731	6,350
Oklahoma, Kansas, Missouri	2,395	1,920	1,890	1,779	1,950	1,997	1,995	2,105	2,322	2,273	2,490	2,353	25,469
Texas:													
Inland	1,933	1,712	1,773	1,675	1,819	1,903	1,862	1,783	1,860	1,869	1,926	2,117	22,232
Gulf coast	7,360	8,178	6,974	9,065	8,111	7,440	8,751	8,448	8,324	8,114	6,934	10,402	98,101
Total	9,293	9,890	8,747	10,740	9,930	9,343	10,613	10,231	10,184	9,983	8,860	12,519	120,333
Louisiana-Arkansas:													
Louisiana gulf coast	3,466	3,147	2,911	3,001	3,053	3,459	2,907	2,685	2,902	3,214	2,920	3,065	36,730
Arkansas and Louisiana inland	639	666	392	580	628	563	605	618	564	500	595	597	6,947
Total	4,105	3,813	3,303	3,581	3,681	4,022	3,512	3,303	3,466	3,714	3,515	3,662	43,677
New Mexico	117	120	124	127	114	142	164	162	140	153	143	118	1,624
Other Rocky Mountain	1,151	1,061	1,086	960	614	1,040	1,050	1,040	944	908	1,009	1,038	11,901
West coast	1,569	1,480	1,384	1,095	1,155	1,114	1,195	1,173	1,137	1,145	1,447	1,739	15,633
Total United States	22,571	23,001	20,888	21,471	20,846	21,537	22,007	21,539	21,395	21,964	21,790	26,442	265,451

[1]Comprises plant condensate (including imports), natural gasoline, LPG, and isopentane.

Table 11.—Production, stocks, and demand of liquefied gases and ethane at gas processing plants and refineries, in 1976

(Thousand barrels)

	Ethane	Propane	Butane	Butane-propane mixtures	Isobutane	Total
Production:						
At gas processing plants	133,654	189,614	81,370	2,557	30,171	437,366
At refineries:						
For fuel use	--	65,055	14,411	4,757	--	84,223
For chemical use	5,639	25,646	5,630	790	2,640	40,345
Total	139,293	280,315	101,411	8,104	32,811	561,934
Net change in stocks:						
Liquefied petroleum gases:						
At gas processing plants	+6,586	-6,582	-4,548	+46	-1,356	-5,854
At refineries	--	+203	-1,402	-1	-613	-1,813
Liquefied refinery gases:						
For fuel use	--	-1,676	+397	+107	--	-1,172
For chemical use	--	+16	-34	+2	+2	-14
Imports	--	24,768	22,668	--	--	47,436
Exports	--	4,766	4,227	--	--	8,993
Used at refineries	--	4,517	56,661	1,889	32,193	95,260
Domestic demand:						
At gas processing plants	127,068	211,478	49,100	623	--	388,216
At refineries:						
For fuel use	--	66,731	14,014	4,650	--	85,395
For chemical use	5,639	25,630	5,664	788	2,585	40,359
Total	132,707	303,839	68,778	6,061	2,585	513,970
Yearend stocks:						
Liquefied petroleum gases:						
At gas processing plants	13,600	69,442	16,450	918	6,307	106,717
At refineries	--	295	923	13	1,158	2,389
Liquefied refinery gases:						
For fuel use	--	3,851	2,917	172	--	6,940
For chemical use	--	216	13	2	18	249
Total	13,600	73,804	20,303	1,105	7,483	116,295

Table 12.—Sales of liquefied petroleum gases and ethane in the United States, 1972-76

(Thousand gallons)

	1972	1973	1974	1975	1976
For export	481,698	418,152	379,596	398,496	377,706
For use in gasoline production	3,578,106	3,369,282	3,369,114	3,765,804	4,000,260
For all other uses	21,833,700	22,199,048	21,538,692	20,430,690	21,586,740
United States total	25,893,504	25,986,482	25,287,402	24,594,990	25,964,706
By type:					
Ethane	4,460,442	5,016,606	5,232,444	5,231,016	5,573,694
Propane	13,847,948	13,494,198	13,158,599	r12,433,548	13,414,507
Butane	2,404,659	2,710,600	2,415,333	r2,095,376	2,071,198
Butane-propane mixtures	1,120,651	977,644	732,316	670,750	527,341
By principal uses:					
Residential and commercial	8,253,340	7,845,991	7,231,035	7,019,989	7,313,023
Internal-combustion	1,479,190	1,409,302	1,309,750	1,162,396	1,169,766
Industrial[1]	1,124,263	1,094,898	1,069,319	r1,081,929	1,051,753
Utility gas	302,481	344,436	356,848	402,752	445,947
Chemical[2]	10,358,858	10,977,239	10,654,038	9,403,057	9,658,488
Miscellaneous[3]	315,568	527,182	917,702	r1,360,567	1,947,763

rRevised.
[1]Includes refinery fuel.
[2]Includes synthetic rubber.
[3]Includes secondary recovery of petroleum, agriculture uses, and use as substitute natural gas feedstock.

Table 13.—Refinery input and stocks of natural gas plant products and refinery output and stocks of liquefied refinery gases, by product, in 1976[1]

(Thousand barrels)

	PAD district																
	I			II					III						IV	V	
	East coast	Appalachian #1	Total	Appalachian #2	Indiana, Illinois, etc.	Minnesota, Wisconsin, etc.	Oklahoma, Kansas, etc.	Total	Texas inland	Texas gulf	Louisiana gulf	Arkansas, Louisiana inland, etc.	New Mexico	Total	Other Rocky Mt.	West coast	United States
Natural gas plant products:																	
Refinery inputs:																	
Propane	--	--	--	--	--	43	11	54	--	1,881	2,568	--	6	4,455	3	5	4,517
Isobutane	--	51	51	655	6,668	1,046	5,829	14,198	4,728	6,337	3,901	747	225	15,938	703	1,303	32,193
Normal butane	11	--	11	747	7,949	853	5,026	14,575	1,712	7,254	14,758	301	100	24,125	764	2,704	42,179
Other butane	10	124	134	--	3,769	1,499	2,354	7,622	242	728	234	47	--	1,251	2,594	2,881	14,482
Butane-propane mix	--	--	--	--	77	--	--	77	--	1,199	235	--	200	1,634	136	42	1,889
Natural gasoline	--	11	11	--	4,856	1,117	12,009	17,982	15,308	75,074	13,668	1,630	1,022	106,702	1,645	5,980	132,320
Plant condensate	--	2,313	2,313	151	13,072	1,792	240	15,255	98	5,772	1,366	4,222	71	11,529	6,056	2,718	37,871
Total	21	2,499	2,520	1,553	36,391	6,350	25,469	69,763	22,088	98,245	36,730	6,947	1,624	165,634	11,901	15,633	265,451
Stocks at refineries:[1]																	
Propane	--	--	--	--	--	--	--	--	--	--	257	--	--	257	38	--	295
Isobutane	--	--	--	40	45	20	236	341	35	39	645	9	3	731	31	55	1,158
Normal butane	--	--	--	57	15	24	254	350	1	15	363	--	--	379	17	115	861
Other butane	--	--	--	--	--	4	20	24	7	--	8	--	--	15	23	--	62
Butane-propane mix	--	--	--	--	2	--	--	2	--	--	7	--	4	11	--	--	13
Natural gasoline	--	2	2	--	39	36	174	249	414	718	164	11	29	1,336	13	18	1,618
Plant condensate	--	--	--	--	666	62	--	728	--	196	--	36	3	235	103	--	1,066
Total	--	2	2	97	767	146	684	1,694	457	968	1,444	56	39	2,964	225	188	5,073

See footnotes at end of table.

Table 13.—Refinery input and stocks of natural gas plant products and refinery output and stocks of liquefied refinery gases, by product, in 1976[1] —Continued

(Thousand barrels)

	PAD district															
	I			II					III						IV	V	
	East coast	Appalachian #1	Total	Appalachian #2	Indiana, Illinois, etc.	Minnesota, Wisconsin, etc.	Oklahoma, Kansas, etc.	Total	Texas inland	Texas gulf	Louisiana gulf	Arkansas, Louisiana inland, etc.	New Mexico	Total	Other Rocky Mt.	West coast	United States
Liquefied refinery gases:																	
Refinery outputs:																	
Propane and/or propylene	15,407	842	16,249	400	18,406	2,124	7,113	28,043	2,758	19,863	10,816	673	192	34,302	1,552	10,555	90,701
Butane and/or butylene	2,692	539	3,231	--	357	217	421	995	645	6,622	2,949	356	--	10,572	540	4,703	20,041
Butane-propane mix	3	175	178	--	384	--	227	611	92	443	3,196	35	336	4,102	60	596	5,547
Isobutane	--	--	--	--	--	--	7	7	94	2,525	--	--	--	2,619	14	--	2,640
Total	18,102	1,556	19,658	400	19,147	2,341	7,768	29,656	3,589	29,453	16,961	1,064	528	51,595	2,166	15,854	118,929
Stocks at refineries:[1]																	
Propane and/or propylene	854	5	859	2	856	12	378	1,248	102	180	998	5	1	1,286	316	358	4,067
Butane and/or butylene	9	1	10	--	86	17	217	320	127	253	1,525	41	--	1,946	100	554	2,930
Butane-propane mix	--	--	--	--	--	--	83	83	--	5	3	--	7	15	2	74	174
Isobutane	--	--	--	--	--	--	--	--	--	9	--	--	--	9	9	--	18
Total	863	6	869	2	942	29	678	1,651	229	447	2,526	46	8	3,256	427	986	7,189

[1]Stocks as of December 31, 1976.

Table 14.—Refinery input of LPG, by product and PAD district

(Thousand barrels)

Item	PAD district I	II	III	IV	V	United States
1974						
Propane	--	--	3,442	10	13	3,465
Normal butane	233	12,137	13,573	361	2,806	29,110
Isobutane	36	11,685	15,927	865	2,316	30,829
Other butanes	73	7,276	3,089	1,928	1,489	13,855
Butane-propane mix	34	61	1,932	443	488	2,958
Total LPG	376	31,159	37,963	3,607	7,112	80,217
1975						
Propane	1	--	3,823	20	82	3,926
Normal butane	91	13,192	17,989	316	3,468	35,056
Isobutane	29	13,027	19,933	932	1,839	35,760
Other butanes	43	7,266	2,368	2,014	1,956	13,647
Butane-propane mix	--	48	870	353	2	1,273
Total LPG	164	33,533	44,983	3,635	7,347	89,662
1976						
Propane	--	54	4,455	3	5	4,517
Normal butane	11	14,575	24,125	764	2,704	42,179
Isobutane	51	14,198	15,938	703	1,303	32,193
Other butanes	134	7,622	1,251	2,594	2,881	14,482
Butane-propane mix	--	77	1,634	136	42	1,889
Total LPG	196	36,526	47,403	4,200	6,935	95,260

Table 15.—Liquefied refinery gases and ethane produced at refineries for fuel and chemical use, in 1976

(Thousand barrels)

States and PAD districts	Ethane	Propane	Butane	Butane-propane mixture	Total
District I:					
New Jersey	27	5,550	1,176	--	6,753
Pennsylvania	--	7,185	1,136	3	8,324
Other States[1]	--	3,514	919	175	4,608
Total District I	27	16,249	3,231	178	19,685
District II:					
Illinois	--	10,444	99	--	10,543
Indiana	--	438	201	--	639
Kansas	464	3,292	336	80	4,172
Kentucky	--	676	--	--	676
Michigan	--	1,351	1	384	1,736
Ohio	--	5,748	56	--	5,804
Oklahoma	--	3,486	57	147	3,690
Other States[2]	--	2,608	252	--	2,860
Total District II	464	28,043	1,002	611	30,120
District III:					
Alabama and Mississippi	--	1,843	1,192	897	3,932
Arkansas	--	289	45	--	334
Louisiana:					
Gulf	971	9,289	1,757	2,299	14,316
Inland	--	68	311	35	414
Total Louisiana	971	9,357	2,068	2,334	14,730
New Mexico	--	192	--	336	528
Texas:					
Gulf	3,457	19,863	9,147	443	32,910
Inland	215	2,758	739	92	3,804
Total Texas	3,672	22,621	9,886	535	36,714
Total District III	4,643	34,302	13,191	4,102	56,238

See footnotes at end of table.

Table 15.—Liquefied refinery gases and ethane produced at refineries for fuel and chemical use, in 1976 —Continued

(Thousand barrels)

States and PAD districts	Ethane	Propane	Butane	Butane-propane mixture	Total
District IV:					
Colorado	--	139	169	--	308
Montana	--	495	136	23	654
Utah	--	761	80	--	841
Wyoming	--	157	169	37	363
Total District IV	--	1,552	554	60	2,166
District V	505	10,555	4,703	596	16,359
Total United States	5,639	90,701	[3]22,681	5,547	124,568

[1]Includes Delaware, New York, Virginia, and West Virginia.
[2]Includes Minnesota, Missouri, Nebraska, North Dakota, Tennessee, and Wisconsin.
[3]Includes 2,640,000 barrels of isobutane used for petrochemical feedstocks.

Table 16.—Stocks of natural gas liquids and ethane in the United States

(Thousand barrels)

Date	LP gases and ethane: At plants and terminals	LP gases and ethane: At refineries	Natural gasoline and isopentane: At plants and terminals	Natural gasoline and isopentane: At refineries	Other finished products and plant condensate: At plants and terminals	Other finished products and plant condensate: At refineries	Total at plants and terminals	Total at refineries	Grand total
Dec. 31:									
1972	74,859	3,077	3,384	1,418	995	510	79,238	5,005	84,243
1973	88,109	2,813	5,075	1,085	922	936	94,106	4,834	98,940
1974	102,518	4,093	5,218	1,262	641	563	108,377	5,918	114,295
1975	112,571	4,202	4,903	1,314	740	548	118,214	6,064	124,278
1976:									
Jan. 31	98,062	3,702	5,073	1,535	572	506	103,707	5,743	109,450
Feb. 29	94,920	3,878	5,199	1,297	571	782	100,690	5,957	106,647
Mar. 31	98,725	3,793	5,374	1,928	588	1,075	104,687	6,796	111,483
Apr. 30	104,000	3,671	5,308	1,746	647	1,416	109,955	6,833	116,788
May 31	110,953	4,303	5,533	1,796	562	1,222	117,048	7,321	124,369
June 30	118,460	4,969	5,499	1,963	585	883	124,544	7,815	132,359
July 31	125,584	5,316	5,560	1,555	540	966	131,684	7,837	139,521
Aug. 31	129,953	5,310	5,774	1,731	594	990	136,321	8,031	144,352
Sept. 30	133,247	5,050	5,879	1,712	521	1,132	139,647	7,894	147,541
Oct. 31	131,241	4,100	5,487	1,820	511	949	137,239	6,869	144,108
Nov. 30	122,597	3,744	5,502	2,163	578	940	128,677	6,847	135,524
Dec. 31	106,717	2,389	5,031	1,618	508	1,066	112,256	5,073	[1]117,329

[1]Includes 81,768,000 barrels in underground storage.

Table 17.—Average monthly prices, liquefied petroleum gas (propane) in the United States

(Cents per gallon)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average for year
New York Harbor:[1]													
1973	9.18	9.18	9.18	9.36	9.48	10.42	10.89	10.89	12.14	11.69	12.37	13.38	10.68
1974	17.75	20.81	18.24	18.24	18.24	19.57	20.89	20.35	15.74	15.80	17.74	17.74	18.43
1975	17.74	17.74	17.74	19.81	20.74	20.74	21.09	21.74	22.20	22.74	23.24	23.24	20.73
1976	23.24	23.65	23.71	22.44	22.44	21.97	22.56	22.74	22.97	23.74	24.57	24.74	23.23
Baton Rouge, La.:[1]													
1973	6.21	6.40	6.91	7.26	8.49	9.16	9.25	9.25	10.07	11.50	11.85	13.28	9.13
1974	16.57	16.12	13.50	13.48	13.48	16.67	19.28	19.02	15.64	15.67	16.64	16.64	16.06
1975	16.64	16.64	16.64	17.21	16.99	16.62	17.84	19.17	19.53	19.65	20.68	20.75	18.19
1976	20.77	19.75	19.75	19.75	19.75	20.14	20.42	20.50	20.97	20.97	21.71	22.13	20.55
Oklahoma:[1]													
1973	5.67	5.90	6.46	6.93	8.30	9.28	9.50	9.50	11.40	13.83	13.83	13.86	9.58
1974	16.36	16.34	13.71	13.59	13.59	16.55	18.54	16.94	13.29	13.00	13.00	13.50	14.87
1975	13.50	13.50	13.50	13.93	14.79	15.79	15.98	16.82	16.89	17.17	17.86	17.96	15.64
1976	18.10	18.21	17.98	17.67	17.71	18.71	18.05	17.69	19.13	19.13	19.18	19.58	18.43
Mt. Belview, Tex.:[2]													
1973	6.02	6.21	6.74	7.22	8.39	9.44	9.88	9.88	10.78	12.79	12.97	14.43	9.56
1974	16.67	16.31	14.48	14.48	14.48	16.49	18.59	17.25	16.33	16.00	15.85	15.85	16.06
1975	15.85	15.85	15.85	15.70	15.89	16.67	17.23	20.54	21.36	21.63	21.63	21.63	18.32
1976	21.63	21.06	19.87	19.13	19.13	19.13	19.50	19.15	20.09	20.09	20.09	20.45	19.94
Wood River, Ill.:													
1973	6.96	6.96	7.15	8.09	8.71	8.79	8.79	8.79	11.08	13.56	15.03	16.81	10.06
1974	18.23	17.84	16.34	16.34	16.34	16.34	17.31	17.34	17.34	17.34	17.34	17.34	17.12
1975	17.34	17.34	17.34	17.34	17.34	19.03	19.15	19.04	19.66	19.85	20.96	21.04	18.79
1976	21.04	20.96	20.56	20.55	20.64	21.05	21.05	21.05	21.30	21.55	21.60	21.67	21.08
Los Angeles, Calif.:													
1973	6.72	6.72	6.86	6.92	6.92	7.78	7.78	7.78	7.78	9.50	10.33	12.74	8.15
1974	13.33	13.98	15.95	15.95	15.95	17.08	17.95	17.95	17.95	17.95	17.95	17.95	16.66
1975	17.95	17.95	17.95	17.95	17.95	15.82	16.01	16.80	18.27	19.00	19.00	19.00	17.70
1976	19.55	17.00	17.00	17.00	17.00	18.30	18.30	18.30	18.30	18.30	18.30	18.30	17.97

[1]Producers' net contract price after discounts and summer-fill allowances in tank cars and transport trucks.
[2]For pipeline input, minimum 10,000 barrels.

Source: Platt's Oil Price Handbook and Oilmanac, 53d ed., 1977.

Table 18.—LPG[1] and plant condensate imported into the United States, by country

(Thousand barrels)

	1974	1975	1976
LPG:			
By country:			
Algeria	(2)	891	2,336
Angola	--	5	--
Australia	--	--	618
Belgium	--	4	--
Brunei	--	23	12
Canada	30,384	30,295	35,189
France	(2)	142	104
Gaza Strip	--	26	--
Hawaii Trade Zone	6	79	375
Indonesia	32	62	8
Iran	13	88	34
Kuwait	--	946	372
Malaysia	24	--	--
Mexico	--	--	16
Netherlands	276	--	--
Netherlands Antilles	575	27	--
Nigeria	55	71	--
Oman	16	31	4
Saudi Arabia	1,836	3,028	2,317
Singapore	35	40	--
United Kingdom	84	4	127
Venezuela	11,634	4,965	5,924
Yemen	1	--	--
Total	44,971	40,727	47,436
By PAD district:			
District I	5,958	6,716	6,066
District II	19,304	17,894	21,938
District III	9,566	5,386	6,773
District IV	5,535	5,706	5,888
District V	4,608	5,025	6,771
Plant condensate:			
Canada	31,840	26,972	24,190
Venezuela	524	--	218
Total	32,364	26,972	24,408
Total LPG and plant condensate	77,335	67,699	71,844

[1]Includes LRG.
[2]Less than 1/2 unit.

Source: Imports of condensate as reported to the Bureau of Mines, other data are compiled from the U.S Department of Commerce, Bureau of the Census.

Table 19.—LPG[1] exported from the United States, by country

(Thousand barrels)

Country	1975				1976			
	Butane	Propane	Butane propane mixtures	Total	Butane	Propane	Butane propane mixtures	Total
Algeria	166	(2)	--	166	--	1	--	1
Argentina	--	--	--	--	(2)	(2)	--	(2)
Australia	5	(2)	1	6	--	4	1	5
Bahamas	--	1	--	1	(2)	3	--	3
Canada	10	9	23	42	38	87	62	187
Chile	--	--	--	--	--	--	1	1
Denmark	--	(2)	--	(2)	--	--	1	1
Dominican Republic	--	--	--	--	(2)	--	--	(2)
Greece	--	--	--	--	(2)	--	--	(2)
Guatemala	--	3	3	6	--	1	4	5
Guyana	--	--	--	--	--	(2)	--	(2)
Honduras	--	--	--	--	--	(2)	--	(2)
Hong Kong	--	--	--	--	(2)	--	(2)	(2)
Israel	--	2	--	2	(2)	--	1	1
Italy	--	--	(2)	(2)	--	2	(2)	2
Jamaica	--	(2)	--	(2)	(2)	--	--	(2)
Japan	--	(2)	1	1	--	--	--	--
Jordon	--	--	--	--	--	(2)	--	(2)
Kuwait	--	--	--	--	--	--	(2)	(2)
Libya	--	--	--	--	--	(2)	--	(2)
Mexico	351	2,126	6,711	9,188	215	2,012	6,519	8,746
Netherlands	--	(2)	--	(2)	--	1	--	1
Netherlands Antilles	--	--	--	--	(2)	--	--	(2)
New Zealand	--	--	--	--	--	(2)	--	(2)
Panama	--	--	--	--	(2)	(2)	--	(2)
Peru	--	(2)	3	3	1	--	(2)	1
Philippines	--	--	--	--	--	--	(2)	(2)
Puerto Rico	1	1	4	6	1	3	25	29
Samoa	--	--	--	--	--	(2)	--	(2)
Saudi Arabia	--	--	--	--	--	--	4	4
South Africa, Republic of	--	2	--	2	1	(2)	(2)	1
Spain	--	(2)	--	(2)	--	--	--	--
Thailand	--	--	--	--	--	(2)	--	(2)
Trinidad	--	--	--	--	--	--	(2)	(2)
Turk Islands	--	--	--	--	--	1	--	1
Venezuela	--	(2)	1	1	(2)	1	(2)	1
Virgin Islands	51	1	7	59	--	1	1	2
Other	--	5	--	5	--	1	--	1
Total	584	2,150	6,754	9,488	256	2,118	6,619	8,993

[1]Data includes LRG.
[2] Less than 1/2 unit.

Source: U.S. Department of Commerce, Bureau of the Census.

Table 20.—Natural gas plant liquids:

(Thousand 42-gallon

Country[1]	1974					
	Propane	Butane	Subtotal	Natural gasoline and other	Total	Propane
North America:						
Canada	33,035	[r]21,775	54,810	59,504	114,314	34,232
Mexico[2]	NA	NA	23,484	4,932	28,416	NA
Trinidad and Tobago	--	--	--	[e]57	[e]57	--
United States	206,539	123,616	330,155	285,943	616,098	200,573
South America:						
Argentina	1,433	1,525	2,958	476	3,434	1,539
Bolivia	NA	NA	65	78	143	NA
Brazil[2]	--	--	--	1,699	1,699	--
Chile[2]	1,834	1,203	3,037	1,962	4,999	1,780
Colombia	1,268	718	1,986	1,338	3,324	2,811
Ecuador	NA	NA	63	109	172	NA
Peru	210	5	215	453	668	NA
Venezuela[2]	NA	NA	21,521	9,075	30,596	NA
Europe:						
Austria	--	--	--	[e]220	[e]220	--
Czechoslovakia	NA	NA	NA	29	29	NA
France	[r]1,814	[r]1,922	[r]3,736	[r]3,939	[r]7,675	1,651
Germany, West	NA	NA	58	76	134	NA
Hungary	NA	NA	[r]1,032	751	[r]1,783	NA
Italy	--	--	--	615	615	--
Netherlands	--	--	--	1,074	1,074	--
Poland	NA	NA	46	390	436	NA
Romania[e]	NA	NA	NA	3,900	3,900	NA
U.S.S.R.[e 2]	NA	NA	NA	NA	83,000	NA
United Kingdom	NA	NA	NA	3,059	3,059	NA
Yugoslavia	NA	NA	577	129	706	NA
Africa:						
Algeria[e 2]	NA	NA	700	11,400	12,100	NA
Libya	335	1,888	2,223	4,119	6,342	NA
Tunisia	--	--	--	--	--	--
Asia:						
Afghanistan[e]	NA	NA	NA	NA	15	NA
Brunei	155	31	186	2,514	2,700	132
Burma	NA	NA	NA	NA	[e]10	--
Indonesia[e]	NA	NA	12	38	50	NA
Iran	NA	NA	[e]7,400	[e]5,700	[e]13,100	3,290
Iraq[e]	NA	NA	NA	NA	2,300	NA
Japan	NA	NA	172	41	213	NA
Kuwait	NA	NA	[e]14,500	[r e]5,650	[r e]20,150	NA
Pakistan	NA	NA	NA	30	30	NA
Qatar[e]	--	--	--	20	20	NA
Saudi Arabia	NA	NA	[e]37,800	[e]11,700	[e]49,500	NA
Taiwan	381	258	639	194	833	353
Oceania:						
Australia[e]	NA	NA	14,000	3,300	17,300	NA
New Zealand	13	12	25	NA	25	NA
Total[3]	[r]247,017	[r]152,953	[r]521,400	[r]424,514	[r]1,031,239	246,361

[e]Estimate. [p]Preliminary. [r]Revised. NA Not available.

[1]In addition to the countries listed, the People's Republic of China may also produce natural gas liquids, but information is inadequate to make reliable estimates of output levels. Every effort has been made to include in this table only those natural gas liquids produced by natural gas processing plants, and to exclude natural gas liquids obtained from field treatment facilities including wellhead separators, because the latter are normally blended with crude oil and thus are in statistics on crude oil output. In some cases, however, sources do not clearly specify whether data presented represent only output of natural gas processing plants or if they include field output. Thus, some of the figures in this table may include field condensate. Where this appears to be the case, the country has been so footnoted, but it may also be true in the case of other countries.

[2]May include field condensate.

[3]Total of listed figures only, and as such represents an incomplete total, due to the fact that in the case of some countries, only total of butane and propane or only total natural gas plant liquids are reported in sources, and insufficient data are available to estimate the distribution of the totals by individual type. Summation of totals of propane and butane thus does not equal the reported natural gas plant liquid total.

World production by country

barrels)

1975				1976[p]				
Butane	Subtotal	Natural gasoline and other	Total	Propane	Butane	Subtotal	Natural gasoline and other	Total
22,411	56,643	55,463	112,106	34,016	22,451	56,467	48,516	104,983
NA	26,897	5,768	32,665	NA	NA	6,441	27,713	34,154
--	--	61	61	--	--	--	53	53
120,568	321,141	274,817	595,958	189,614	114,098	303,712	283,333	587,045
1,687	3,226	472	3,698	1,802	2,010	3,812	[e]475	4,287
NA	144	86	230	NA	NA	[e]217	43	[e]260
--	--	1,931	1,931	--	--	--	[e]2,000	[e]2,000
1,205	2,985	1,696	4,681	1,755	1,132	2,887	1,604	4,491
734	3,545	1,324	4,869	3,041	666	3,707	1,094	4,801
NA	53	139	192	NA	NA	[e]50	128	178
NA	NA	NA	664	NA	NA	NA	NA	660
NA	18,904	10,131	29,035	9,270	8,251	17,521	7,544	25,065
--	--	182	182	--	--	--	191	191
NA	NA	29	29	NA	NA	NA	[e]30	[e]30
1,847	3,498	4,042	7,540	1,613	1,782	3,395	3,956	7,351
NA	46	38	84	NA	NA	NA	NA	90
NA	846	1,299	2,145	NA	NA	NA	NA	[e]2,500
--	--	408	408	--	--	--	405	405
--	--	1,463	1,463	--	--	--	1,663	1,663
NA	58	285	343	NA	NA	NA	NA	[e]400
NA	NA	[r]3,990	[r]3,990	NA	NA	NA	NA	3,900
NA	NA	NA	90,000	NA	NA	NA	NA	100,000
NA	NA	NA	1,691	NA	NA	NA	NA	3,658
NA	622	134	756	NA	NA	[e]626	[e]147	[e]773
NA	788	17,100	17,900	NA	NA	NA	NA	18,000
NA	NA	NA	[e]6,000	NA	NA	NA	NA	[e]7,000
--	--	--	--	--	--	--	2	2
NA	NA	NA	15	--	--	--	9	9
11	143	2,963	3,106	141	3	144	4,604	4,748
--	--	11	11	NA	NA	NA	NA	[e]10
NA	12	38	50	NA	NA	NA	NA	70
3,705	6,995	5,031	12,026	3,170	3,673	6,843	5,283	12,126
NA	NA	NA	2,600	NA	NA	1,687	955	2,642
NA	222	37	259	NA	NA	293	37	330
NA	12,876	4,532	17,408	7,711	6,832	14,543	5,305	19,848
NA	NA	NA	[r][e]25	NA	NA	NA	NA	[e]32
NA	1,600	900	2,500	NA	NA	NA	NA	2,800
NA	[e]39,400	[e]11,300	[e]50,700	NA	NA	NA	NA	67,628
205	558	176	734	391	238	629	214	843
NA	NA	NA	[r]19,300	NA	NA	NA	NA	22,700
NA	NA	34	34	NA	NA	52	34	86
152,373	501,202	405,880	1,027,389	252,524	161,136	423,026	395,338	1,047,812

Nickel

By John D. Corrick[1]

There was a gradual improvement in demand for nickel during 1976; however, the supply of nickel proved more than adequate, as newly developing projects gathered momentum in Australia, the Philippines, Botswana, and the United States. At yearend, nickel remained in oversupply, and some major producers were cutting back production or continuing to operate below capacity.

U.S. nickel consumption increased 11% in 1976 over that of 1975; however, stocks of consumer-held nickel remained at a relatively high level. A surge in consumer-held stocks in the second half of the year could be attributed to nickel purchases being made in advance of price increases. Ferronickel increased its share of the total U.S. market in 1976 at the expense of pure unwrought nickel and recovered that share of the market that was lost in 1975. The pattern of nickel consumption remained essentially unchanged in 1976 from that of previous years.

The price of pure nickel was increased by 21 cents per pound on October 1; however, the old price of $2.20 per pound prevailed until 1977 for major consumers of nickel. Similar price increases were announced for domestically and foreign produced ferronickel at about the same time. Near yearend, most major nickel producers were offering class II products at prices reduced from those announced in October on firm orders for delivery during the first quarter of 1977.

World trade in nickel picked up during 1976 in line with the gradual increase in demand. Imports of nickel into the United States in 1976 increased 17% compared with 1975 imports. Leading suppliers of nickel to the United States, in descending order, were Canada, Botswana, Norway, the Dominican Republic, New Caledonia, and the Philippines.

Legislation and Government Programs.— During 1976 a bill was passed and signed into law closing the Glacier Bay National Monument in Alaska to new mining claims and effectively placing all existing mining claims under tight regulations, to be administered by the U.S. Department of the Interior.

[1]Physical scientist, Division of Ferrous Metals.

Table 1.—Salient nickel statistics

(Short tons, contained nickel)

	1972	1973	1974	1975	1976
United States:					
Mine production[1]	16,864	18,272	16,618	16,987	16,469
Plant production:					
Primary	15,731	13,895	14,093	14,343	13,869
Secondary	35,926	32,629	20,930	17,880	13,273
Exports (gross weight)	21,671	22,070	30,442	30,121	47,561
Imports for consumption	173,978	190,418	220,655	160,507	188,147
Consumption	159,286	197,723	208,409	146,495	162,927
Stocks, Dec. 31: Consumer	26,260	28,759	45,291	35,485	31,596
Price ____ cents per pound	133-158	153	153-201	201-220	220
World: Mine production	673,817	782,588	r849,257	r867,943	886,337

rRevised.
[1]Mine shipments.

DOMESTIC PRODUCTION

Domestic production of nickel was on the increase as output at the AMAX Inc. nickel refinery at Port Nickel, La., continued to rise. According to the company's annual report, nickel production reached 20,000 short tons in 1976, or 50% of capacity. The one domestic mine, operated by Hanna Mining Co. at Riddle, Oreg., produced 16,469 tons of nickel from laterite ore, as measured by mine shipments. Nickel recovered at the Hanna smelter and byproduct nickel salts and metals produced at copper and other metal refineries amounted to 13,869 tons; part of the byproduct originated from scrap. Exploration for nickel in 1976 took place in the Katahdin massive sulfide deposit in Maine, Glacier Bay National Monument in southern Alaska, the Precambrian rocks of Wyoming, Montana, and Colorado, the Duluth gabbro of Minnesota, and Red Mountain in California near the Oregon border. Officials of AMAX Exploration, Inc. reported that work on its Minnamax project to evaluate copper-nickel mineralization near Babbitt, Minn., was progressing satisfactorily. In March 1976, a contract for sinking a 14-foot-diameter shaft to 1,710 feet was awarded to Centennial Development Co. A headframe was erected during the summer and shaft sinking began. By December the shaft had reached 670 feet and the contractor was averaging 10 feet per day. After the shaft is completed, planned underground development work would determine the continuity of the copper-nickel mineralization and the mining and environmental parameters. A 20,000 ton bulk sample would be mined for concentrating and metallurgical tests. Hanna Mining Co. reportedly acquired 5,000 acres on Red Mountain in northern California and staked mining claims on another 3,400 acres under the control of the U.S. Bureau of Land Management.

International Nickel, Inc., formed a new wholly-owned subsidiary, The International Metals Reclamation Co., Inc. (Inmetco), to convert specialty steelmaking waste into commercially useful metals. The facility is to be located at Ellwood City, Pa., 35 miles northwest of Pittsburgh, Pa., and will be within the U.S. Steel Corp.'s industrial park. The reclamation unit, to be completed by mid-1978, will have a capacity to process 40,000 tons per year of specialty steel mill waste. Flue dust, grinding swarf, and mill scale will be processed into a nickel-chromium stainless steel remelt alloy. The wastes currently are being discarded as landfill.

Universal Oil Product Co.'s (UOP) Tucson Technical Development Center completed its pilot plant for treating lateritic ores in 1976. The pilot plant has a nominal capacity of 5 tons of ore feed per day. Reportedly, mine-run ore can be received, crushed, dried and ground, reductively roasted, and leached to produce various commercial nickel products.

Table 2.—Primary nickel produced in the United States

(Short tons, contained nickel)

	1972	1973	1974	1975	1976
Byproduct of metal refining	2,505	958	873	[1]14,343	[1]13,869
Domestic ore	13,226	12,937	13,220		

[1]Combined to conceal individual company confidential data.

CONSUMPTION AND USES

The slower than anticipated recovery in demand for nickel during 1976 resulted in consumers delaying purchases of nickel while working off high levels of stocks. Stocks reached a yearly low of 42 million pounds at the end of June, then increased during the remainder of 1976 to a yearend level of 63 million pounds. The second-half surge in consumer-held stocks could be attributed to nickel purchases being made in advance of price increases.

Ferronickel increased its share of the total U.S. nickel market in 1976 at the expense of pure unwrought nickel and recovered that share of the market that was lost in 1975. Pure unwrought nickel accounted for 64% of the total nickel consumed in 1976, compared with 68% in 1975 and 59% in 1974. Most of the pure nickel was consumed in the production of nickel wrought products and nickel alloys, and in electroplating. Ferronickel accounted for

Table 3.—Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery

(Short tons, contained nickel)

Kind of scrap	1975	1976	Form of recovery	1975	1976
New scrap:			As metal	1,979	701
Nickel-base	3,123	1,691	In nickel-base alloys	2,623	2,470
Copper-base	5,222	4,189	In copper-base alloys	7,032	6,565
Aluminum-base	1,251	1,499	In aluminum-base alloys	1,318	1,478
			In ferrous and high-temperature alloys[1]	4,205	1,138
Total	9,596	7,379	In chemical compounds	723	921
Old scrap:					
Nickel-base	7,825	5,372	Total	17,880	13,273
Copper-base	375	415			
Aluminum-base	84	107			
Total	8,284	5,894			
Grand total	17,880	13,273			

[1]Includes only nonferrous scrap added to ferrous high-temperature alloys.

19% of the total nickel consumed in 1976 compared with 17% in 1975 and 22% in 1974. Principal consumption of ferronickel was in stainless and alloy steels.

Domestic nickel consumption increased by nearly 11% in 1976 compared with that of 1975. The pattern of nickel consumption in 1976 was as follows: 30% in stainless and heat-resisting steels, 20% in other nickel and nickel alloys, 18% in electroplating, 12% in alloy steel, and 6% in superalloys.

Table 4.—Stocks and consumption of new and old nickel scrap in the United States in 1976

(Gross weight, short tons)

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New	Old	Total	
Smelters and refiners:						
Nickel and nickel alloys	86	6,392	1,899	4,014	5,913	599
Nickel copper metal	260	1,377	666	660	1,326	311
Nickel silver[1]	699	2,896	359	2,553	2,912	683
Cupronickel[1]	90	147	--	173	173	64
Nickel residues	34	W	W	W	W	W
Total	380	7,769	2,565	4,674	7,239	910
Foundries and other manufacturers:						
Nickel and nickel alloys	r64	1,962	902	831	1,733	293
Nickel copper metal	13	296	--	276	276	33
Nickel silver[1]	3,095	19,148	19,254	24	19,278	2,965
Cupronickel[1]	1,833	14,303	14,537	--	14,537	1,599
Nickel residues	116	455	40	428	468	103
Total	r193	2,713	942	1,535	2,477	429
Grand total:						
Nickel and nickel alloys	r150	8,354	2,801	4,845	7,646	892
Nickel copper metal	273	1,673	666	936	1,602	344
Nickel silver[1]	3,794	22,044	19,613	2,577	22,190	3,648
Cupronickel[1]	1,923	14,450	14,537	173	14,710	1,663
Nickel residues[r]	150	455	40	428	468	103
Total	r573	10,482	3,507	6,209	9,716	1,339

[r]Revised. W Withheld to avoid disclosing individual company confidential data; included in nickel and nickel alloys.
[1] Excluded from totals because it is copper-base scrap, although containing considerable nickel.

Table 5.—Nickel (exclusive of scrap) consumed in the United States, by form

(Short tons, contained nickel)

Form	1972	1973	1974	1975	1976
Metal	110,422	121,821	123,996	99,693	104,374
Ferronickel	22,806	36,371	45,661	25,325	31,210
Oxide powder and oxide sinter	19,315	33,257	33,617	16,630	22,198
Salts[1]	3,939	3,668	2,026	1,751	2,437
Other	2,804	2,606	3,109	3,096	2,708
Total	159,286	197,723	208,409	146,495	162,927

[1]Metallic nickel salts consumed by plating industry are estimated.

Table 6.—U.S.consumption of nickel (exclusive of scrap) in 1976, by use and form

(Short tons, contained nickel)

Use	Commercially pure unwrought nickel	Ferronickel	Nickel oxide	Nickel sulfate and other nickel salts	Other forms	Total
Steel:						
Stainless and heat-resisting	13,564	21,503	13,337	--	214	48,618
Alloys (excludes stainless)	5,535	7,394	5,933	--	261	19,123
Superalloys	8,686	175	16	--	236	9,113
Nickel-copper and copper-nickel alloys	7,166	10	31	--	143	7,350
Permanent magnet alloys	4,319	1,401	70	--	--	5,790
Other nickel and nickel alloys	29,992	344	1,701	15	476	32,528
Cast irons	2,022	382	507	1	1,096	4,008
Electroplating[1]	26,783	--	15	1,871	16	28,685
Chemicals and chemical uses	1,787	--	352	463	--	2,602
Other uses[2]	4,520	1	236	87	266	5,110
Total reported by companies canvassed and estimated	104,374	31,210	22,198	2,437	2,708	162,927

[1]Based on monthly estimated sales to platers.
[2]Includes batteries, ceramics, and other alloys containing nickel.

Table 7.—Nickel (exclusive of scrap) in consumer stocks in the United States, by form

(Short tons, contained nickel)

Form	1974	1975[r]	1976[p]
Metal	25,862	19,702	18,346
Ferronickel	11,511	11,210	6,839
Oxide powder and oxide sinter	6,189	3,378	5,259
Salts	457	564	498
Other	1,272	631	654
Total	45,291	35,485	31,596

[p]Preliminary. [r]Revised.

Table 8.—Consumption, stocks, receipts, shipments and/or sales of secondary nickel in 1976, by use

(Short tons, contained nickel)

Use	Receipts	Consumption	Shipments or sales	Stocks, end of year
Steel (stainless and heat-resisting and alloy)	35,259	35,102	1,523	3,155
Nonferrous alloys (super, nickel-copper and copper-nickel, permanent magnet, and other nickel)	3,362	3,319	1	579
Foundry (cast irons)	480	479	--	44
Chemicals (catalysts, ceramics, plating salts, and other chemical uses)	22	26	--	5
Total reported by companies canvassed and estimated	39,123	38,926	1,524	3,783

PRICES

The price of pure nickel was increased to $2.41 per pound effective October 1; however, the old price of $2.20 per pound prevailed until 1977 for the major consumers of nickel.

The price of domestically produced ferronickel was increased from $2.16 per pound of contained nickel to $2.34 per pound effective October 1. Late in November, Hanna announced an allowance of 8 cents per pound on its price for ferronickel, applicable to all firm orders for delivery during the first quarter of 1977. The price of foreign produced ferronickel was reflected in N. C. Trading Co.'s price increases effective October 1. The new prices, f.o.b. Baltimore, Md., follow: FN4, $2.35 per pound of nickel content; FNC, $2.37 per pound of nickel content; and FN3, $2.39 per pound of nickel content. Near yearend most major nickel producers were offering class II products at prices reduced from those announced in October on firm orders for delivery during the first quarter of 1977.

FOREIGN TRADE

The gross weight of U.S. exports of nickel, nickel alloys, and nickel catalysts was 58% more in 1976 than in 1975. Exports of unwrought nickel in 1976 more than doubled over that exported in 1975.

Canada remained the principal supplier of nickel to the United States in 1976, and accounted for 58% of the total. The next most important sources of imported nickel, in decreasing order of magnitude, were Botswana, Norway, the Dominican Republic, New Caledonia, and the Philippines. The ascension of Botswana and the Philippines as notable supply sources of nickel for the United States was directly related to their newly developed nickel industries. These five countries accounted for 88% of the total nickel imported in 1976. Imports (based on contained nickel) of ferronickel decreased from 13% of the total imports in 1975 to 9% in 1976, while unwrought nickel decreased from 67% in 1975 to 59% in 1976. The total of all forms imported for consumption in 1976 was 17% more than in 1975.

Table 9.—U.S. exports of nickel and nickel alloy products, by class

Class	1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Unwrought	3,174	$11,522	6,676	$25,281	14,948	$67,226
Bars, rods, angles, shapes, and sections	3,852	21,290	3,400	22,132	2,519	15,634
Plates, sheets, and strip	8,524	49,857	5,808	44,402	4,397	37,631
Anodes	543	2,066	275	940	331	1,598
Wire	1,117	6,056	679	4,769	769	5,253
Powder and flakes	571	6,037	429	4,575	488	6,150
Foil	19	56	26	54	17	89
Catalysts	3,477	9,143	3,536	13,713	4,442	16,282
Tubes, pipes, blanks, and fittings therefor, and hollow bars	2,903	17,226	2,333	15,791	3,702	24,497
Waste and scrap	6,262	10,245	6,959	9,645	15,948	19,635
Total	30,442	133,498	30,121	141,302	47,561	193,995

Table 10.—U.S. imports for consumption of nickel products, by class

Class	1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ore	62	$2	1,135	$47	6,706	$341
Unwrought	137,314	450,342	107,084	406,894	111,255	456,398
Oxide and oxide sinter	6,449	15,081	5,063	15,172	5,932	21,948
Slurry[1]	42,999	96,959	23,991	63,522	33,280	98,178
Bars, plates, sheets, and anodes	342	1,665	[r]517	3,272	776	4,372
Rods and wire	696	3,722	960	5,804	1,774	9,896
Shapes, sections, and angles	7	46	10	81	5	16
Pipes, tubes, and fittings	339	2,066	265	1,961	668	6,064
Powder	9,316	33,344	9,749	39,328	10,046	44,687
Flakes	55	201	23	85	135	580
Waste and scrap	3,699	8,545	2,353	5,864	2,359	4,827
Ferronickel	102,430	87,255	65,046	67,813	55,721	72,161
Total (gross weight)	303,708	699,228	[r]216,196	609,843	228,657	719,468
Nickel content (estimated)[2]	220,655	XX	160,507	XX	188,147	XX

[r]Revised. XX Not applicable.

[1]Nickel-containing material in slurry, or any form derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.

[2]Estimated from gross weight of primary nickel products.

Table 11.—U.S.imports for consumption of new nickel products, [1] by country

(Short tons)

Country	Metal (gross weight)		Powder and flakes (gross weight)		Oxide and oxide sinter (gross weight)		Slurry and other[2]			
							1975		1976	
	1975	1976	1975	1976	1975	1976	Gross weight	Nickel content	Gross weight	Nickel content
Australia	2,844	3,684	1,819	1,218	1,032	--	155	141	735	670
Canada	79,984	77,819	4,533	6,280	3,939	5,843	15,550	11,789	26,233	19,637
Dominican Republic	16	133	--	--	--	--	--	--	--	--
Finland	775	844	--	--	--	--	--	--	46	40
France	42	9	--	34	20	59	--	--	--	--
Germany, West	34	(3)	(3)	7	20	2	--	--	79	16
Japan	251	848	--	--	30	--	--	--	360	276
Netherlands	61	43	36	(3)	(3)	(3)	--	--	--	--
New Caledonia[4]	--	--	--	--	--	--	8,167	6,213	5,727	4,383
Norway	11,180	13,913	165	264	--	--	--	--	--	--
Philippines	3,019	6,972	1,540	1,209	--	--	--	--	--	--
Rhodesia, Southern	2,766	3,103	--	--	--	--	--	--	--	--
South Africa, Republic of	3,173	2,661	606	308	--	--	--	--	--	--
Switzerland	--	19	--	1	--	--	--	--	--	--
U.S.S.R	2,467	1,055	--	--	--	--	--	--	--	--
United Kingdom	400	82	1,073	860	2	8	119	57	100	25
Other	72	70	--	(3)	20	20	--	--	--	--
Total	107,084	111,255	9,772	10,181	5,063	5,932	23,991	18,200	33,280	25,047

[1]Ore imports in 1975 were 1,135 tons, all from New Caledonia. Ore imports in 1976 were 6,687 tons from New Caledonia and 19 tons from Canada.
[2]Nickel-containing material in slurry, or in any form derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.
[3]Less than 1/2 unit.
[4]Formerly French Pacific Islands.

WORLD REVIEW

Australia.—Western Mining Corp. Ltd. increased production and purchases of nickel by about 9% to 47,837 tons. The increase was mainly due to the Windarra operation building up to full production. Enlargement of the Kalgoorlie smelter to 35,000 tons of nickel annually was completed during the year. The Kwinana refinery capacity was increased to 30,000 tons of refined metal annually. The ammonia plant at the refinery was completed. According to a company spokesman, sales of nickel in all forms during 1976 were 39,381 tons, a slight increase from the 38,600 tons sold in 1975. Poseidon Ltd., which shares a 50% interest in the Windarra nickel mine and concentrator with Western Mining, experienced financial problems during 1976 and was placed in receivership in October. Collapse of the company was the result of increasing costs and a depressed nickel demand that restrained prices. At yearend, the future of Poseidon was uncertain. The Australian Industrial Development Corp. (AIDC), to which Poseidon owed some $25 million, had stated that it would take an equity interest in the venture if no satisfactory sale could be made. It appeared that AIDC would continue to put money into the Windarra project to insure that a future buyer for Poseidon's share would be taking over a viable company. Windarra's proved and probable reserves were estimated at nearly 10 million tons of nickel sulfide ore averaging 1.49% nickel.

Although still experiencing some problems in mid-1976, the Greenvale metallurgical plant at Yabulu in Queensland, was approaching designed capacity. The Greenvale mine and plant generated a cash flow in 1976. The company was able to obtain this position only by virtue of debt restructuring and supplemental financing arranged in mid-1975. Freeport Minerals Co., a partner in the project, reported that output of nickel, in the form of nickel oxide, amounted to nearly 10 million pounds during the third quarter, or about 86% of capacity. The reason for not reaching capacity was the shutdown of the ammonia plant for its annual inspection during August. The output of nickel and cobalt in mixed sulfides amounted to 1,239,000 and 490,000 pounds, respectively, or about 69% of capacity. These sulfides were exported to Japan for refining. Reportedly, the poor financial performance today has been the result of rising Australian labor costs and world fuel prices. A further restructuring of Greenvale's finances was announced late in 1976. Interest payments on the company's debts were scheduled to resume during the first quarter of 1977, but capital repayment has been deferred until 1979. Overall operating capacity for 1976 was given as 80% to 90%.

At yearend 1976, the Premier of Western Australia and the joint owners in the Agnew nickel project, Western Selcast Pty. Ltd. and Mount Isa Mines Ltd., announced the completion of arrangements that will enable the project to proceed toward production. The facilities at Agnew will have an initial annual capacity to produce 10,000 tons of nickel concentrate. Production is expected to begin in late 1978. The nickel concentrate, grading 10% to 11% nickel, will be freighted 200 miles north to Western Mining Corp.'s smelter at Kalgoorlie. Spokesmen for Western Mining stated that the two partners in the Agnew venture would advance a substantial part of the funds needed for expanding the capacity of the Kalgoorlie smelter. The expansion will enable the smelter to smelt up to 110,000 tons per year of concentrate from the Agnew mine, beginning in 1979. Initially mining will take place in the higher grade shoot, 1A, which contains about 2.2 million tons of ore assaying 3.5% to 5% nickel.

Australian geologists reported the discovery of a large deposit of manganese nodules on the ocean floor 300 miles west of the Australian coast in an area known as the Scott Plateau. Reportedly, the deposit covers about 230,000 square miles. The nodules are somewhat lower in grade than the nodules from areas of the central Pacific. The combined nickel and cobalt values range from 0.32% to 1.44% and average 1.19%. The nodules are found at a depth of approximately 16,000 feet. The attractive feature of the Australian deposit is its close proximity to Fremantle, the shipping port for the State capital of Perth.

Botswana.—During the year, progress was made toward overcoming process and technical problems that have plagued the Selebi-Pikwe copper-nickel project for the past 4 years. During the first 6 months of 1976, copper-nickel matte production rose to 16,766 tons from 7,088 tons in the comparable period of 1975. At the end of 1976,

Table 12.—Nickel: World mine production[1] by country

(Short tons, contained nickel)

Country	1974	1975	1976[p]
Albania[e]	6,600	6,600	6,600
Australia (content of concentrate)	[r]50,685	83,548	91,652
Botswana	13,042	18,314	13,866
Brazil (content of ore)	[r]3,898	3,516	3,400
Burma (content of speiss)	24	21	26
Canada[2]	296,600	266,957	289,348
Cuba (content of oxide and sulfide)[e]	[r]37,400	40,300	40,800
Dominican Republic	[r]33,620	29,652	26,896
Finland:			
Content of concentrate	6,352	5,957	[e]6,830
Content of nickel sulfate	205	228	209
Germany, East[e]	2,400	[r]2,800	2,800
Greece (recoverable content of ore)[3]	31,440	31,014	30,380
Indonesia (content of ore)[3]	[r]23,251	21,193	19,600
Mexico (content of ore)	28	55	62
Morocco (content of nickel ore and cobalt ore)	550	550	550
New Caledonia (recoverable)[4]	148,333	146,767	117,506
Norway (content of concentrate)	[r]591	335	[e]660
Philippines	359	10,472	20,723
Poland (content of ore)[e]	2,200	[r]2,800	2,800
Rhodesia, Southern (content of concentrate)[e]	12,700	11,000	16,500
South Africa, Republic of	24,361	22,877	24,660
U.S.S.R. (content of ore)[e]	[r]138,000	[r]146,000	154,000
United States (content of ore shipped)	16,618	16,987	16,469
Total	[r]849,257	867,943	886,337

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Insofar as possible, this table represents mine production of nickel, where data relates to some more highly processed form, the figures given have been used in lieu of unreported actual mine output to provide some indication of the magnitude of mine output, and are so noted parenthetically following the country name.
[2]Refined nickel and nickel content of oxides and salts produced, plus recoverable nickel in exported matte and speiss.
[3]Includes a small amount of cobalt not reported separately.
[4]Nickel-cobalt content of metallurgical plant products, plus recoverable nickel-cobalt in exported ores.

Table 13.—Nickel: World smelter production,[1] by country

(Short tons, contained nickel)

Country[2]	1974	1975	1976[p]
Australia	22,000	37,500	52,900
Botswana	2,899	7,099	[e]13,000
Brazil[3]	2,636	2,513	2,200
Canada[3]	[r]220,352	196,211	193,676
Cuba[e 3]	[r]16,400	20,000	22,000
Czechoslovakia[e]	900	900	1,000
Dominican Republic[4]	34,400	33,100	28,219
Finland	7,115	7,214	8,404
France	[r]9,592	11,968	11,354
Germany, East[e]	2,400	[r]2,900	2,800
Germany, West	161	134	143
Greece	16,600	16,343	18,131
Japan	[r]115,296	85,980	102,956
Mexico	28	55	62
New Caledonia[5]	[r]74,263	78,339	68,245
Norway	47,646	40,847	36,028
Philippines	--	10,322	15,763
Poland[e]	2,200	[r]2,800	2,800
Rhodesia, Southern[e]	11,000	[r]10,000	11,000
South Africa, Republic of	18,700	11,000	16,500
United Kingdom	39,400	41,116	36,514
U.S.S.R	[r]160,000	[r]168,000	176,000
United States:			
Byproduct of metal refinery	873	[6]14,343	[6]13,869
Recovery from domestic ore	13,220		
Total	[r]818,081	798,684	833,564

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Refined nickel plus nickel content of ferronickel produced from concentrates unless otherwise specified.
[2]In addition to the countries listed, North Korea is believed to produce metallic nickel and/or ferronickel, but information is inadequate for formulation of reliable estimates of output levels.
[3]Includes nickel content of nickel oxide and nickel fonte in addition to metallic nickel and ferronickel.
[4]Nickel content of ferronickel only (no refined nickel is produced).
[5]Includes nickel content of metallurgical products exported.
[6]Individual figures for byproduct of metal refinery and recovery from domestic ore are withheld as company confidential information.

production was running at 70% of capacity; full production was expected early in 1977. A scheduled shutdown for furnace maintenance, planned for mid-1976, was postponed until April 1977, as the plant continued to operate satisfactorily.

Brazil.—Brazil has significant deposits of lateritic nickel. Most of the deposits are located in central Goiás, where total reserves are estimated in excess of 200 million tons of ore containing 1.5% nickel. One project was under development in 1976, two others were in various stages of evaluation, and three others were in advanced exploration stages. Construction was well underway on a $35 million first stage project of Cia. Niquel Tocantins. This was scheduled for startup in 1978. Production will be in the form of 5,000 tons per year of electrolytic nickel; an additional 5,000-ton-per-year capacity is to be installed approximately 2 years later. Nickel carbonate is to be produced at the plant, located near the mine site at Niquelandia. The nickel carbonate will be shipped to an electrolytic plant being built in São Paulo.

Baminco Mineraçãoe Siderúrgia S.A. (BAMINCO), a joint venture between INCO, Ltd. and a West German consortium that includes several steel companies and Metallgesellschaft A.G., was in the final stages of evaluating a nickel project located at Barro Alto, approximately 85 miles northwest of Brasilia. The project would have a capacity of 55,000 tons per year of ferronickel containing about 22,000 tons of nickel. Total investment in the project was estimated at $300 million. Production could start as soon as 1980. The other project being evaluated was that of Empresa de Desenvolvimento de Recursos Minerais (CODEMIN) near Niquelandia. If de eloped, the project would produce 10,600 tons per year of electrolytic nickel at an investment of $140 million.

Mineradora Montita Ltd. was exploring a deposit at Jussara during 1976. Companhia de Pesquisas de Recursos Minerais (CPRM), a federally owned minerals exploration company, was exploring two nickel deposits during 1976. Reportedly, if exploration results appear to justify a project, CPRM will ask for public bids for development of the properties. The two deposits being explored are located at Montes Carlos de Goiás and Jussara.

Burundi.—Speculation persisted during 1976 as to the size of nickel discoveries in Burundi. At yearend, most interested parties were still awaiting the results of a prefeasibility study, which may be completed by mid-1977. Results of this study and prevailing estimates of the market situation concerning the current and future consumption of nickel should provide interested companies with a basis for deciding whether to involve themselves financially in the development effort. Any project in Burundi would involve mining, metallurgical processing, electric power supply, and complete infrastructure development. Cost of the project could approach $750 million by completion.

Canada.—Mine production of nickel in Canada in 1976 amounted to 289,348 tons, compared with 266,957 tons produced in 1975. Canada remained the leading producer of nickel in the world and accounted for 32.6% of the total world mine production. The principal producers of nickel in Canada were INCO, Falconbridge International Ltd., and Sherritt Gordon Mines Ltd. Late in 1975, the provincial government of Ontario granted the mining industry a tax relief of between $8 and $10 million per year. Under the terms of the new concession, companies will be permitted to deduct foreign processing costs for tax purposes for a period of 5 years from the date the initial regulation on foreign processing was introduced.

INCO mined a total of 19.8 million tons of ore having an average nickel content of 1.41% in 1976, compared with 21.2 million tons having an average nickel content of 1.40% in 1975. Nickel production by INCO in 1976 was reported to be 231,000 tons, compared with 229,500 tons in 1975. Nickel production was somewhat less than expected as a result of two work stoppages at Thompson, totaling 14 days. The stoppages were in protest of the Anti-Inflation Board's rollback of wage increases granted under a collective bargaining agreement signed on February 25, 1976. INCO reported proven reserves in Canada of 412 million tons, containing 6.8 million tons of nickel and 4.4 million tons of copper. The company operated 15 mines during 1976, 12 in Ontario and 3 in Manitoba. Three mines were being maintained on a standby basis, two in Ontario and one in Manitoba. Mine development work continued during 1976 on the Levack East and the Clarabelle open pit extension. The Levack East mine is scheduled to begin production in 1983, while the Clarabelle, an extension of a mine that previously had been in production, was expected to be working again by 1978. The Victoria mine resumed production in April 1976. The small Kirkwood mine ceased production in March 1976 upon depletion of minable ore. Planning was completed at yearend on the construction of a $27 million ventilation system for the 75-year-old Creighton mine. At the Manitoba Division, development work continued on the three operating mines, Birchtree, Pipe, and Thompson. Construction on a new rolling mill in the Sudbury district of Ontario was started in March 1976 and was about 70% complete by yearend. The mill is scheduled to be in production by mid-1977. The rolling mill will direct-roll metal powders into nickel and cupronickel alloy strip for primary use as coinage. INCO's investment in the mill will be about $29 million. During 1976, INCO opened two water treatment plants in the Sudbury area. The two plants were constructed at a cost of $6 million as part of a new tailings disposal facility which will cost a reported $36 million. The combined capacity of the two treatment plants was reported as 67 million gallons per day. Reportedly, INCO's Ontario division uses recycled water for 87% of its requirements. Company officials reported that nickel inventories at yearend were equivalent to a 5 to 6 months' supply, compared with a normal level of 2 to 3 months' supply.

Falco and Sherritt Gordon remained the number 2 and 3 producers, respectively, of nickel in Canada in 1976. Falco continued a curtailment of nickel production throughout 1976 at its Sudbury operations. The East, Onaping, Fecunis, and Longvack South mines, the Fecunis mill, and one of two smelter blast furnaces remained idle throughout 1976. At yearend, work was started to reactivate the Longvack South mine. Ore deliveries to treatment plants from Falco's mines in the Sudbury area amounted to 3,219,000 tons in 1976, compared with 3,041,000 tons in 1975. The Manibridge mine in Manitoba produced 208,000 tons, compared with 189,000 tons the previous year. However, this mine will be closed during the first half of 1977 as the ore reserves become exhausted. The newly opened Lockerby property had reached 40% of capacity at yearend 1976. Falco's smelter operated one blast furnace and two converters throughout the year. Oxygen enrichment of the blast air was started in February in order to increase the throughput of the one furnace operation. The expansion program at the Strathcona mill was completed, raising the capacity to 8,500 tons per day. Work on the Fraser No. 1 shaft, which was halted on August 21, 1975, was resumed in August 1976. At yearend, the shaft was approximately 5,000 feet below the collar, and plans were underway for sinking a ventilation shaft. The $95 million Smelter Environmental Improvement Program at the Sudbury operations was restarted in August. At yearend, erection of steel for the new smelter building was essentially completed, the building was 50% closed in, and erection of vessels for the associated acid plant was 50% finished. Expenditures on this project at the end of 1976 totaled $31,751,000. The construction program is to be completed by the spring of 1978. Falco reported ore reserves as being 5,694,000 tons lower than at the end of 1975; however, there was a small increase in the grade. Reportedly, the loss of marginal ore from reserves reflected increased production costs which were not offset by a corresponding increase in the price of metals. Ore reserves in 1976 were reported as 83,405,000 tons grading 1.46% nickel (1,214,000 tons of nickel) compared with 89,099,000 tons grading of 1.43% nickel (1,279,000 tons of nickel) in 1975. The Dumbarton mine in the Bird River area of eastern Manitoba, 50% owned by Falco, was closed down in 1976. The underground operations were shut down several years ago, but the underground crushing facilities at the mine were used to reduce ore from the open pit nearby. Ore already mined was expected to be cleaned up by mid-1976. Some 600,000 tons of ore had been mined from the pit, averaging 1.17% nickel and 0.2% copper. Reportedly, Falco was exploring another nickel-copper occurrence some 8 miles northeast of the Dumbarton mine site.

Sherritt Gordon announced the planned shutdown of the Farley nickel-copper mine at Lynn Lake, Manitoba. Salvage work at the mine was estimated to require 6 months. The mill and surface plant were to be put on standby so that they could be reactivated if a new discovery was made within an economic distance of Lynn Lake. The major reason for the mine's unprofitability was that the tonnage and grade of ore were too low to generate sufficient revenues to cover escalating operating costs. The Farley mine had been operating since 1953 but recently was operating at about 1,200 tons per day, or one-third of its rated capacity. The closure will have some impact on the firm's Fort Saskatchewan nickel refinery, since concentrate from the mine would have provided about 15% of the refinery's feed for the next few years.

Production, as measured by sales and deliveries and reported by the three principal Canadian producers in 1976, follow:

Company	Type of operation	Thousand pounds
The International Nickel Co. of Canada, Ltd.	Delivery	409,830
Falconbridge Nickel Mines, Ltd.	do	83,615
Sherritt Gordon Mines, Ltd.	Sales	22,454

Teck Corp. reported a new nickel-copper discovery 35 miles northwest of Timmins, Ontario. Members of the exploration syndicate, each with a third working interest, were Teck Corp., Metallgesellschaft Canada Ltd., and Domik Exploration Ltd. of Japan. Thus far, nickel content of core samples has ranged from 0.6% to 2.8% with about 0.5% copper. An unusual find was announced in the Key Lake area of northern Saskatchewan by Uranerz Exploration and Mining Co., then a subsidiary of Uraniz-Bergbau GmbH of West Germany, Inexco Oil Co., Houston, Tex., and Saskatchewan Mining Development Corp., a provincial crown corporation. The ore body, which has been sampled with over 173 core holes, has shown an average grade of 3% U_3O_8 and 3.5% nickel. However, grades as high as 45% for both minerals have been recorded. A mine and mill are presently under consideration but will have to comply with the yet-to-be defined Provincial government requirements.

During the year, Boliden A.B. of Stockholm, Sweden, showed its faith in the Great Lakes nickel project by acquiring the largest single share in the company. Boliden bought an additional 22% of the shares in Great Lakes Nickel from the Canadian investment firm of 246057 Investments Ltd. Boliden expects to maintain the project on a standby basis until world demand and prices of nickel are right for its development.

Colombia.—The prospects for the 50-million-pound-per-year nickel project at Cerro Matoso starting up by 1980, appear to depend upon the world demand for nickel improving during the next few years. Pilot plant studies conducted at Riddle, Oreg., by Hanna have demonstrated the feasibility of using a rotary-kiln electric furnace process to produce ferronickel. Hanna is to be the manager and a co-owner of the nickel project for 25 years. A new Colombian corporation, Econiquel, would hold a one-third interest in the project, while Compania de Nicquel Colombiano S.A., a subsidiary of Conicol Ltd., a Delaware corporation controlled by Hanna, and the Chevron Corp. (20%) would control the remainder. Capital costs for the project are estimated at $300 million.

Cuba.—Construction and renovation of Cuba's Moa Bay and Nicaro nickel plants were underway in 1976. Current plans called for increasing the combined capacities of the two existing plants from 40,000 tons per year to 51,000 tons by 1980. Phase 2 would raise Cuba's nickel capacity to about 117,000 tons per year by 1985 with the addition of two new 33,000-ton plants. The addition of one or two more plants by 1990 could raise the nickel production capacity of Cuba to 165,000 tons. Reportedly, both phases 1 and 2 were underway during 1976. Phase 2 includes the construction of a 33,000-ton-per-year nickel-cobalt oxide plant at Punta Gorda, about 2 miles east of Moa Bay. A similar sized plant would be built 5 miles east of Moa Bay. Completion of the Punta Gorda facility is expected by 1982-83 and the second facility by 1985. Cubaniquel is currently selling 70% of the Nicaro oxide and sinter output to market economy countries; the balance and all of the Moa Bay sulfide output go to Comecon countries. The Cubans were reported to be building a 246-foot dam on the Boa River to ensure a steadier source of water for the plants. Each new plant was expected to employ about 5,000 mine and plant workers. The plants will use the same ammonium carbonate leaching process as used in the 32-year-old Nicaro plant, with some technological improvements. Recovery rates are expected to be more than 80%, compared with 76% at Nicaro.

Dominican Republic.—Falconbridge Dominicana, C. por A., shipped 28,236 tons of contained nickel in 1976, compared with 26,164 tons in 1975. The plant continued to operate satisfactorily, although at a reduced rate because of depressed nickel markets.

Metal output was about 10% below that of 1975. This allowed product inventories to be reduced to an acceptable level. Ore reserves at the end of 1976, on an undiluted in situ basis, were reported to be 72,500,000 tons grading 1.65% nickel. Improvements in ore reserves over those of 1975 resulted from development drilling programs on the major ore bodies, which included ore below the original open pit outline.

Greece.—Société Minière et Métallurgique de Larymna S.A. (LARCO) obtained, in March 1976, Government approval for a $50 million improvement and expansion of its facilities during the next 3 years. The expansion would increase production capacity from the present 15,000 tons to 27,000 tons of nickel per year and would double mine output. LARCO was also planning a subsequent $170 million investment to establish a second plant which will further increase the company's annual nickel production to 40,000 tons. Under the second stage of development, a completely new ferronickel plant on the island of Euboea is planned. Mine output will be increased to 5 million tons per year. Completion of the second stage is currently forecast for 48 months after the first stage of the program is completed.

Guatemala.—Construction of facilities for a lateritic nickel project near Lake Izabal, in eastern Guatemala by Exploraciones y Explotaciones Mineras Izabal, S.A. was nearly 95% complete at yearend 1976. Mining began in 1976, and the ore was stored for trial runs during the spring of 1977. Production of nickel matte was scheduled for the third quarter of 1977, and the plant was to reach the planned annual rate of 14,000 tons of nickel in matte in early 1978. The estimated cost of the project remained at $224 million. Financing arrangements were made during 1976 and were approved by the Guatemalan authorities. INCO is the majority shareholder and operator of the project; the government and Hanna also own shares in the company. Basic Resources International S.A. was considering developing nickel properties it holds in Guatemala. One of Basic's properties was adjacent to INCO's Lake Izabal property. According to company officials, discussions were held during 1976 on the possibility of developing a 30,000 ton-per-year operation in the country. The company stated a need for a partnership with a major nickel producer with expertise in smelting lateritic ores on a large scale.

Indonesia.—Construction of stage 1 of the lateritic nickel project of P. T. International Nickel Indonesia, a majority-owned INCO subsidiary, was completed at Soroako on the island of Sulawesi at yearend 1976. Nickel matte was scheduled for shipment during the summer of 1977. Production of the stage 1 unit was planned to be 17,500 tons of nickel in the form of matte. Stage 2 of the project included the construction of two additional process lines and a hydroelectric installation on the Larona River. These facilities were 40% completed at yearend 1976. Scheduled for production in 1978, the second stage will increase nickel production to 50,000 tons per year. The capital costs for the entire project, including a third 55 megawatt-generating unit at the Larona River hydroelectric plant, were reported as $850 million. Total electrical capacity will then be 165 megawatts.

P. T. Aneka Tambang's (ANEKA) newly constructed ferronickel smelter began production in March 1976. Japanese buyers agreed to purchase only a quarter of the output, contrary to earlier expectations that they would take all of it. The smelter will utilize ores that fall below export grade, thus prolonging the life of the mine for an indefinite period. The ferronickel will contain 20% to 25% nickel and cobalt. The smelter is capable of producing either a relatively expensive low-carbon ferronickel, which is difficult to produce; or a high-carbon product, for which buyers are harder to find. The plant cost $54.8 million and can process 350,000 tons per year of low-grade lateritic ore into 20,000 tons of ferronickel containing 4,000 to 4,250 tons of nickel. Operation of the plant will guarantee the survival of the nickel mines on Pomalaa, because the plant is based on using the lower grade ore that is not exportable. Officials of ANEKA were holding discussions at yearend 1976 with the Japanese in an attempt to conclude a contract for ferronickel imports during 1977.

A third project, P. T. Pacific Nikkel Indonesia, has the designed potential of producing 49,900 tons of metallic nickel annually, and the firm reportedly was making steady progress toward assembling financing for the project.

The Japanese-owned Indonesian Nickel Development Company (INDECO), with a Contract of Work on Gebe Island, informed Indonesian authorities that its findings do not show that a mining project there would be viable under economic conditions as they existed in 1976.

At mid-1976, the Mining Department of Indonesia announced that no further foreign investment would be permitted for nickel mining in Indonesia.

Japan.—The Nikko Nickel Cobalt Smelting Co., Ltd., established in September 1975, began commercial production of metallic cobalt and nickel at Hitachi, Ibaragi Prefecture, in 1976. The facilities are capable of producing 3,300 tons of nickel and 1,320 tons of metallic cobalt per year. The firm became the third largest producer of metallic nickel in Japan. Sumitomo Metal Mining Co., Ltd., began commercial production of nickel and cobalt at its Besshi plant, Ehime Prefecture, in 1976. The feed for the plant was from mixed sulfides imported from Marinduque Mining and Industrial Corp. in the Philippines. Plant capacity was reported as 2,770 tons of nickel and 1,760 tons of cobalt per year. Both companies use a solvent extraction process for separating cobalt and nickel from the mixed sulfides. Shimura Kako Co., Ltd., the second largest producer of electrolytic nickel in Japan (30% owned by INCO), announced plans in 1976 to build a new nickel electrolytic plant (capacity to be 11,000 tons), and a nickel sulfate plant (capacity of 1,100 tons contained nickel) at its Date plant in Hokkaido by the end of 1978. The company will close its Shimura plant (present capacity 8,000 tons of electrolytic nickel).

In March 1976, four Japanese ferronickel producers completed a $2 million, 2-year joint study on the production of ferronickel from laterites. The process includes pelletization of lateritic ore, followed by heating of the pellets in an annular vertical kiln prior to smelting to recover nickel. Although applicable to low-grade garnierite ore, the process has not been used in Japan. However, Pacific Metals planned to construct a ferronickel plant at Niigata, capable of producing 19,800 tons per year by 1978; the plant would have the largest electric furnace (60,000-kilovolt-amperes) in Japan. Reportedly, the company has invited the other four ferronickel producers to join in the project.

The Japanese Government imposed a 13% tariff on metallic nickel imports, unless the nickel was further refined. Nickel matte imported from Canada and Australia during the year contained about 25% sulfur and therefore definitely required refining. Consequently, no import duty would be applied under the regulations. However, the matte from Soroako, Indonesia, containing only 7% to 8% sulfur, could be used directly in making steel. Thus, the 13% tariff would be applicable to the low-sulfur matte, unless it was further refined.

New Caledonia.—Production of nickel ore in New Caledonia in 1976 was 12% less than that produced in 1975 and totaled 6.5 million tons. Nickel smelter production decreased 13% in 1976 from that of 1975 and totaled 68,245 tons. Ferronickel production decreased nearly 28% and totaled 42,044 tons, while matte production increased 30% over that of 1975. Exports of nickel ore to Japan increased 9% in 1976 compared with exports in 1975, reflecting a slight improvement in the world demand for nickel during 1976. Exported ore averaged 2.38% nickel plus cobalt.

During 1976, Société Métallurgique Le Nickel (SLN) played host to worldwide customers, Government officials, and journalists at the SLN facilities in New Caledonia and explained the firm's new projects and plans for meeting future demand for nickel. SLN had a capacity in 1976 to produce about 70,000 tons of nickel per year in the form of ferronickel and matte. SLN is to begin a $230 million expansion in 1977 that will eventually increase capacity of the Doniambo smelter to about 110,000 million tons. Ore production is to increase to about 1.3 million tons per year at Konaona and 2.2 million tons per year at Nepoui. The improvements at Doniambo will include ore preparation and calcination facilities. In addition to the New Caledonian improvements, the company will construct a new nickel refinery in the Sandouville-LeHarve industrial complex of France to produce 15,000 tons per year of high-purity nickel cathodes. Marketing of the high-purity nickel was scheduled for mid-1978.

Development of the large lateritic nickel deposits on the north side of New Caledonia (Poum and Tiebaghi deposits) moved forward during 1976 when Patino N.V. of the Netherlands agreed to sell to the French state-owned Bureau de Recherches Géologiques et Minières (BRGM) 90% of its share in Compagnie Française d'Entreprises Minières Métallurgiques et d'Investissements (COFREMMI). COFREMMI was to undertake the development of the deposits. Tentative plans called for the development of a 33,000- to 44,000-ton-per-year mining and metallurgy complex. The site would be at Koumac. Originally, BRGM was to complete previous studies begun by COFREMMI. Under BRGM's new approach, the firm will decide the final combination of possible processes, as submitted by companies interested in the project, to be used in conjunction with its own continuing studies. Reportedly, Amax and Péchiney Ugine Kuhlmann were interested in the deposits. INCO, which holds an option on a major share of the southeastern Goro deposits, reported it currently had no plans to join the study phase being conducted on the northern deposits.

Japanese smelter operators were able to secure a 3-month delay on a nickel ore price increase from SLN in October 1976.

Philippines.—Marinduque Mining and Industrial Corp. was still experiencing operating difficulties with its refinery on Nonoc Island during 1976. The refinery was shut down from February 16 until March 14 because of leaks in the waste-heat boiler of the gas plant. Other problem areas were in the reliability of services such as power, steam, hydrogen, and carbon dioxide gases; the training of personnel; roaster availability; materials and parts availability; the first-stage leach circuit cooling capacity; and excessive consumption of ammonia. However, average operating capacity for the first 9 months of 1976 was 48%. From November 14 through December 17, Marinduque shut the plant down for the purpose of installing a new boiler and for annual maintenance.

A joint nickel mining project between Rio Tuba Mining Corp. and Pacific Metals Co. of Japan, on the island of Palawan, was to be brought onstream late in 1976. Shipments of ore to Japan were to begin in January 1977. About 350,000 tons was to be shipped in 1977 and 500,000 tons in 1978. The ore would grade 2.2% nickel.

Rhodesia, Southern.—A $24.7 million expansion program by Rhodesia Nickel Corp. (Rhonickel) was completed in 1976. The Epoch mine started operations in January 1976, and the electric smelting furnace at Bindura was commissioned in November 1975. A new converter at Bindura was brought into operation in February 1976, and the entire expanded refinery was commissioned in mid-April. However, a slag runaway occured a week after the furnace was commissioned. The slag penetrated the main power station and caused a fire and subsequent loss of electrical power to the entire smelter complex. Ore grade from the Shangani mine north of Bulawayo was running less than originally expected due to oxidation in the upper levels of the orebody. The ore is currently being mined by open pit techniques. However, an incline is being sunk to exploit ore reserves below the level at which the open pit method is no longer economic. At yearend, Rhonickel requested permission to borrow an additional R$9 million to finance increased stocks of nickel.

South Africa, Republic of.—Nickel occurs with platinum in the Merensky Reef of the central Transvaal and is recovered by refining a nickel-copper matte at an approximate ratio of 1 ton of nickel to 55 ounces of platinum metal, indicating about 0.2% nickel per ton of ore. The two major producers were Rustenburg Platinum Mines Ltd. and Impala Platinum Ltd. A conservative estimate of nickel reserves in the Merensky Reef suggests a total of 200 million tons of ore containing 400,000 tons of nickel. Additional nickel is believed to be present in the Bushveld Igneous Complex and specifically the Vlakfontein deposit west of Pilanesburg.

Growth of nickel production in South Africa has been erratic owing primarily to its direct dependence upon platinum production. In 1975 22,800 tons of nickel was produced, compared with 24,200 tons in 1976. Data through September 1976 indicated that for 1976, 3,750 tons of nickel would be sold locally and 18,250 tons exported.

U.S.S.R.—Reportedly, equipment deliveries from Finland for the nickel smelter and sulfur plant at Norilsk began during the summer of 1976. Nine tons of engineering material were delivered by truck to Leningrad between March and April of 1976. Specialty equipment would not be delivered until the summer of 1978. The smelter will have a capacity to handle 550,000 tons of nickel concentrate per year.

TECHNOLOGY

Bureau of Mines scientists reported research results on the recovery of nickel, cobalt, and copper from domestic laterites.[2] The report described recent progress by Bureau of Mines scientists on their hydrometallurgical process. The process per-

[2]Siemens, R. E., and J. D. Corrick. Process for Recovery of Nickel, Cobalt and Copper From Domestic Laterites. Min. Cong. J., v. 63, No. 1, January 1977, pp. 29-34.

mits a high metal recovery (about 90%), relatively low energy requirements (for reduction, about 90 million Btu per ton of nickel recovered from laterite containing 1% nickel; and for electrowinning, 9.6 to 13.6 million Btu per ton of nickel) selectivity of metals of interest, no polluting discharges, efficiency of reagent utilization, and recovery of high-purity metals. The process is also applicable to a variety of nickel-, cobalt-, copper-, and zinc-bearing oxide and sulfide ores and secondary sources. Two Bureau of Mines investigative reports on Raney nickel were published during 1976. The first report dealt with investigation of the powder metallurgy of Raney nickel.[3] Factors studied included the typical angular particle shape in conjunction with aluminum present in a eutectic phase, its effect in facilitating the interlocking of particles, and the subsequent excellent green strength after compaction. The effect of compacting pressure on density and porosity was studied over a range of 37.5 to 207 meganewtons per square meter. Also studied was the effect of sintering in an inert atmosphere over the range of 575° to 850° C. A second Bureau report described the method employed to prepare supported Raney nickel catalysts by dip coating.[4] The studies were done in support of research to develop methanation catalysts for converting synthesis gas derived from coal to synthetic natural gas.

Scientists at four Bureau of Mines research centers continued to carry out nickel-related research during 1976. Research programs included studies to determine the potential of increasing domestic production of nickel by applying advanced technology to domestic nickel oxide and nickel-copper sulfide resources. Other areas of interest included nickel and cobalt recovery from Missouri lead ores (from both flotation concentrates and mattes and drosses), the recovery of nickel, cobalt, copper, and manganese from ocean nodules, and processing of the Duluth gabbro nickel-copper sulfide ores. The development of new nickel alloys and the discovery of possible new substitutes for nickel were also being investigated.

A new high-strength, copper-based alloy containing nickel was developed by the Ampco-Pittsburgh Corp.[5] The alloy, containing nickel, aluminum, and bronze, reportedly had greater tensile strength than other commercial copper alloys except for the high-beryllium-content coppers such as CA825 (2% Be). Present applications of the new alloy appear to be in the aerospace industry as bushings and bearings. Their greatest potential lies in alloys used to withstand the combined effect of corrosion and high mechanical demands. Other applications include aircraft landing gear components, hydraulic cylinder linkage bushings for utility trucks used for tree trimmings, valves for pumps used to inject corrosives into rock strata to enhance oil flow, and safety tools and machines used in explosive environments (tools made of this alloy are sparkless). Huntington Alloys, Inc., developed four new alloys for use by the aerospace industry.[6] Two of the alloys, Inconel MA754 and Inconel MA956E, are based on the new technology of mechanical alloying. A third alloy, 903, combines high strength and a low, constant coefficient of expansion. The fourth alloy, Inconel 617, combines high-temperature strength and oxidation-carburization resistance. According to a company spokesman, the new alloys will enable designers to achieve weight reductions and longer life in critical aerospace components. The alloys will probably find use in jet engines and the space shuttle. Another alloy introduced by Huntington, IN-939, is said to more than double the life of turbine blades used in industrial and marine turbines.[7] The alloy was expected to permit the use of cheaper, less refined fuel, and thus reduce operating costs. The advantages of a new range of nickel-based casting alloys, in which boron replaced carbon, were described, along with the production of wrought superalloys, their market, and their nuclear and chemical-petrochemical applications.[8] The effect of 2% cobalt, 1% nickel, and 1% chromium on the hot-rolled microstructure and properties of a bainitic steel containing 0.2% manganese, 1% silicon, 0.75% molybdenum, and 0.003% boron was described.[9] The results showed that nickel did not appear to influence the microstructure, when added

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[3]O'Hare, S. A., W. L. O'Brien, R. B. Worthington, and J. E. Mauser. Powder Metallurgy of Raney Nickel. BuMines RI 8182, 1976, 12 pp.

[4]Oden, L. L., P. E. Sanker, and J. H. Russell. Preparing Supported Raney Nickel Catalysts by Dip Coating. BuMines RI 8184, 1976, 13 pp.

[5]Metal Progress. Strong Copper Alloy Subs for Beryllium Copper. October 1976, pp. 7-8.

[6]American Metal Market. Huntington Develops Four Nickel Alloys to Meet Needs of Aerospace Industry. V. 82, No. 212, Oct. 28, 1976, p. 7.

[7]Metallurgia and Metal Forming. New High Temperature Alloy. V. 43, No. 7, 1976, p. 214.

[8]Molloy, W. J., and D. R. Green. Development Production and Application. Metallurgia and Metal Forming, v. 43, No. 7, 1976, pp. 215-221.

[9]Mangonon, P. L. Effect of Alloying Elements on the Microstructure and Properties of a Hot-Rolled, Low-Carbon, Low-Alloy Bainitic Steel. Metallurgical Trans., v. 7A, No. 9, 1976, pp. 1389-1400.

alone, but in combination with chromium, it enhanced the formation of the lower bainitic structure.

Yardney Electric Corp. stated that it was looking into development of a nickel-zinc battery for use in passenger cars.[10] The company hoped to expand the battery's range and acceleration capabilities with no increase in weight. Reportedly, the nickel-zinc battery had nearly double the energy density of a comparable lead-acid battery. Other companies exploring the potential of nickel-zinc batteries were General Motors Corp. and the National Aeronautics and Space Administration's Lewis Research Center in Cleveland.[11] Raney nickel has been used as a catalyst for hydrogen electrodes in alkaline hydrogen-oxygen fuel cells. Recent studies have shown that a titanium-containing Raney nickel was capable of significantly increasing the rate of anodic hydrogen conversion in these fuel cells.[12] The report described the properties of the catalyst powder, the effect of particle diameter, and the behavior of electrodes under load. Electrode kinetic parameters were determined for hydrogen and oxygen evolution at 80°, 150°, 208°, and 264° C on nickel electrodes in 50 weight-percent potassium hydroxide (KOH) solutions.[13] The results indicated that significant reductions in cell voltage for water electrolysis can be obtained at higher operating temperatures, and that at temperatures of about 150° C it should be possible to approach 100% energy efficiency.

Ford Motor Co. was exploring the development of the Stirling engine for use in powering its future cars. Reportedly, the materials and technology of the Stirling engine were outgrowths of Ford's turbine developments.[14] Because of the very high temperatures surrounding the combustion chamber, nickel-based alloys were being employed and evaluated.

What may be a significant technological development occurred with the patenting of a process for beneficiating low-grade laterites by a combination of segregation and either magnetic separation or froth flotation.[15] The process requires that a mixture of ground ore, calcium carbonate, calcium sulfate, and coke be sprayed with a solution of sodium chloride, the wet mass pelletized, and the pellets roasted for 90 minutes at a temperature not exceeding 1,050° C. This converts the nickel to a magnetic state. The roasted pellets are ground in a water medium, and the suspension is separated magnetically or by froth flotation to obtain a nickel-rich concentrate. A high level of industrial activity from previous years was again evident from the large number of patents issued during 1976. The patents ranged from mining through beneficiation to extractive metallurgy (both pyro- and hydrometallurgy).

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[10]Smith, A. Yardney Expects U.S. $$ for Nickel-Zinc Battery. Am. Metal Market, v. 83, No. 120, June 18, 1976, p. 7.

[11]Industrial Research. Battery Research Charges Forward. V. 18, No. 13, December 1976, p. 16.

[12]Mund, K., G. Richter, and F. von Sturm. Titanium-Containing Raney Nickel Catalyst for Hydrogen Electrodes in Alkaline Fuel Cell Systems. J. Electrochem. Soc., v. 124, No. 1, January 1977, pp. 1-6.

[13]Miles, M. H., G. Kissel, P. W. T. Lu, and S. Srinivasan. Effect of Temperature on Electrode Kinetic Parameters for Hydrogen and Oxygen Evolution Reactions on Nickel Electrodes in Alkaline Solutions. J. Electrochem. Soc., v. 123, No. 3, March 1976, pp. 332-336.

[14]Weiner, G. A. Stirling Engine: Solution to the U.S. Auto Dilemma? Iron Age, v. 218, No. 21, November 22, 1976, pp. 53-58.

[15]Nestoridia, A. (assigned to Financial Mining - Industrial & Shipping Corp.). U.S. Pat. 4,002,463, January 11, 1977, 8 pp.

Nitrogen

By Russell J. Foster[1]

Domestic production of fixed nitrogen in 1976 was 13.9 million tons, an increase of 2% over that of the previous year. Elemental nitrogen production rose 15% to 10.5 million tons. Exports of fixed nitrogen were up 3%; imports increased 9%. Domestic consumption, including net imports of 136,000 tons, rose 7%. Consumption of elemental nitrogen was considered equal to production.

Table 1.—Salient nitrogen statistics

(Thousand short tons of contained nitrogen)

	1972	1973	1974	1975	1976[p]
United States:					
Production as ammonia [1]	[r]12,616	12,641	[r]13,061	13,617	13,863
Production as elemental nitrogen [2]	7,011	[r]8,229	[r]8,814	9,142	10,503
Exports of nitrogen compounds [3]	1,310	1,506	999	1,235	1,278
Imports for consumption of nitrogen compounds [3]	947	967	1,154	1,296	1,414
Consumption [4]	[r]12,298	[r]12,720	[r]12,987	12,896	13,858
World: Production [3]	47,398	51,500	53,400	54,600	56,900

[p]Preliminary. [r]Revised.
[1]Anhydrous ammonia and coke oven ammonium compounds.
[2]Converted from reported volume (at 70°F and 1 atmosphere pressure) at 27,605 cubic feet per short ton.
[3]Estimated, excludes elemental nitrogen.
[4]Includes producers' stock change in synthetic anhydrous ammonia and coke oven ammonium compounds; excludes elemental nitrogen.

Legislation and Government Programs.—After evaluating data submitted by nitrogen fertilizer producers, the Environmental Protection Agency (EPA) amended its effluent guidelines and standards for the fertilizer industry to allow limited discharges of nitric acid by manufacturers. The amended regulation set limitations in terms of pH, ammonia and nitrate in process waste water based upon data from all identified sources of discharge, and required pH control over noncontact cooling water. The need for a separate regulation for special discharges or for leaks and spills was deemed unnecessary.[2] EPA also proposed amendments to the effluent guidelines and standards for urea and ammonium nitrate.[3]

A committee of the National Research Council Assembly of Life Sciences was studying ammonia for its possible effects on public health. Major sources of ammonia in the atmosphere are natural processes, such as decomposition of organic matter and the release of ammonia from fertilizers. Like some other natural constituents of the atmosphere, ammonia appears hazardous only at high concentrations.[4]

[1]Physical scientist, Division of Nonmetallic Minerals.
[2]Environmental Protection Agency. Fertilizer Manufacturing Point Source Category. Federal Register, v. 41, No. 11, Jan. 16, 1976, pp. 2386-2388.
[3]———. Fertilizer Manufacturing Point Source Category. Federal Register, v. 41, No. 138, July 16, 1976, pp. 29429-29432.
[4]Chemical Marketing Reporter. Ammonia Being Given Closer Look by NRC for Effects on Health. V. 209, No. 3, Jan. 19, 1976, pp. 3, 44.

DOMESTIC PRODUCTION

Domestic production of fixed nitrogen, primarily as anhydrous ammonia, increased 2% in 1976 to 13.9 million tons. Production of elemental nitrogen rose 15% to 10.5 million tons.

The Federal Power Commission (FPC) established new ceiling prices for interstate natural gas, effective at the beginning of 1976. The price of old gas, defined as gas flowing in interstate pipelines prior to January 1, 1973, was initially permitted to rise to 23.5 cents per 1,000 cubic feet, and on July 1, to 29.5 cents per 1,000 cubic feet. The ceiling price for new gas, that is, gas discovered or committed to interstate commerce after January 1, 1975, was increased by 1 cent to 52 cents per 1,000 cubic feet.[5] A second round of rate adjustments occurred in late July, as FPC raised the ceiling price of new gas to $1.42 per 1,000 cubic feet with a 4-cent annual escalation allowance. Gas discovered or committed to the interstate market after January 1, 1973, and before January 1, 1975, was permitted to go up to $1.01 per 1,000 cubic feet, and old gas could increase to 52 cents per 1,000 cubic feet as contracts expired.[6] The FPC rulings were upheld by a three-judge panel of the District of Columbia Court of Appeals on the condition that contracts include a refund provision.[7]

Canada announced a two-stage price increase of approximately 20% for natural gas exported to the United States. The first rise was implemented on September 1, 1976, lifting prices by 20 cents to $1.80 per 1,000 cubic feet. The second increase became effective at yearend.[8]

The National Weather Service forecasted colder-than-normal temperatures for the winter of 1976-77. A severe winter would necessitate greater demand for natural gas from residential users, and curtail supplies to industrial customers served by interstate pipelines. This could force shifts, where possible, to costlier alternate fuels, and also result in record losses of ammonia production.[9]

Georgia Pacific Corp. awarded a contract to Pullman Kellogg for construction of a 575-ton-per-day ammonia plant at Plaquemine, La. Completion of the $45 million facility was scheduled for late 1978. Byproduct hydrogen from the company's adjacent methanol and chlor-alkali plants will be combined with nitrogen for ammonia production. Utilization of the hydrogen will eliminate the high energy requirement for reforming the more traditional natural gas feedstock.[10]

Construction of a second ammonia plant for Agrico Chemical Co. was begun by Pullman Kellogg at Verdigris, Okla. The new 1,150-ton-per-day plant was scheduled onstream in 1977 adjacent to a recently completed fertilizer complex.[11]

American Cyanamid Co. will complete a new 245,000-ton-per-year ammonia plant at its Fortier, La., complex by mid-1979. The addition will bring capacity to 625,000 tons per year.[12]

A 68,000-ton-per-year ammonia plant was brought onstream by N-Ren Corp. at Carlsbad, N.M., and a 90,000-ton-per-year unit was started up at Taft, La., by Occidental Agricultural Chemical Co. Expansion of ammonia capacity by six other producers at existing plants totaled approximately 184,000 tons per year.[13]

Chevron Chemical Co. awarded a design contract to C & I/Girdler, Inc. for a second ammonium nitrate plant to be built at its Kennewick, Wash., facility, increasing total capacity from 100,000 tons per year to 233,000 tons per year.[14]

Farmland Industries, Inc. brought a 70,000-ton-per-year urea plant and an 80,000-ton-per-year ammonium nitrate unit onstream at Ft. Dodge, Iowa, and Dodge City, Kans., respectively.[15]

Existing urea capacity was increased by over 400,000 tons per year at the facilities of four producers. Ammonium nitrate capacity at two plants was expanded by nearly 100,000 tons per year, including the first commercial implementation of a pan granulation process by N-Ren Corp. at Pryor,

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[5]Chemical Marketing Reporter. FPC Raises Its Ceiling on Natural Gas Prices. V. 209, No. 1, Jan. 5, 1976, p. 4.

[6]———. Gas Price Tripled by FPC; Move Stayed by Appeals Court. V. 210, No. 5, Aug. 2, 1976, pp. 3, 14.

[7]———. FPC Move on Gas Price Is Upheld. V. 210, No. 7, Aug. 16, 1976, pp. 4, 53.

[8]———. Canada Plans Increase in Its Natural Gas Price. V. 209, No. 24, June 14, 1976, p. 5.

[9]Chemical & Engineering News. Cold Winter May Drive Up Plant Fuel Costs. V. 54, No. 51, Dec. 13, 1976, pp. 12, 14.

[10]Chemical Marketing Reporter. Pullman Gets Contract for G-P Ammonia Unit. V. 210, No. 10, Sept. 6, 1976, p. 12.

[11]Chemical Week. Agrico To Get a Second Ammonia Unit at Verdigris. V. 118, No. 18, May 5, 1976, p. 9.

[12]Chemical Marketing Reporter. Ammonia Unit on Slate for American Cyanamid. V. 210, No. 23, Dec. 6, 1976, p. 3.

[13]Distribution Economics Section, Tennessee Valley Authority. World Fertilizer Capacity. Ammonia, Urea, Ammonium Nitrate. Oct. 17, 1977.

[14]Chemical & Engineering News. Checkoff. New Plants. V. 54, No. 25, June 14, 1976, p. 14.

[15]Work cited in footnote 13.

Okla.[16]

The modernization and expansion of nitric acid output at Kaiser Agricultural Chemicals Co.'s Savannah, Ga. complex was completed with the commissioning of a new 165,000-ton-per-year unit.[17] Mississippi Chemical Corp. commissioned a 300,000-ton-per-year nitric acid plant at Yazoo City, Miss.[18]

Hercules, Inc. sold its nitrogen products plant at Hercules, Calif., to Valley Nitrogen Producers, Inc., for $22 million.[19] Mobil Chemical Co. sold its 300,000-ton-per-year ammonia plant and downstream urea and ammonium nitrate units at Beaumont, Tex., to Swift Chemical Co.[20]

Air Products & Chemicals, Inc. began production of liquid nitrogen, oxygen, and argon at two new 300-ton-per-day facilities at LaSalle, Ill., and Conyers, Ga.[21] Air Products planned to bring two more 300-ton-per-day plants onstream at Pryor, Okla., in late 1977, and Greensboro, N.C., in 1978, and will increase the liquid industrial gases capacity of its plant at El Segundo, Calif., to 600 tons per day by mid-1978.[22] The company also announced the construction of a new unit at its LaPorte, Tex., chemical complex by 1979 to pipe 2,100 tons per day of nitrogen and oxygen to Syngas Co. of Deer Park, Tex., and provide 350 tons per day of liquid nitrogen, oxygen, and argon for sale in the Houston area.[23] In addition, Air Products arranged to deliver 300 tons of nitrogen and 250 tons of oxygen per day from a new facility to E. I. duPont de Nemours & Co.'s projected titanium dioxide plant at DeLisle, Miss., beginning in early 1979.[24]

Union Carbide Corp. planned to construct an air separation plant at Fife, Wash. Scheduled for completion in 1978, the new facility will produce 260 tons of liquid nitrogen, oxygen, and argon daily to meet growing demand in the Pacific Northwest.[25] The company brought onstream at Burns Harbor, Ind., the largest single-train air separation unit ever built. High purity gaseous nitrogen and argon will be produced in addition to 2,000 tons per day of oxygen for nearby steelmakers.[26]

The Pace Companies will engineer and construct three air separation plants with a combined value of $70 million for Big Three Industries, Inc. Two plants, at Plaquemine, La., and Channelview, Tex., will have combined capacity of 4,200 tons per day gaseous nitrogen, 1,950 tons per day gaseous oxygen, 300 tons per day liquid nitrogen and liquid oxygen, and 60 tons per day liquid argon. The same liquid nitrogen and oxygen capacity will be added to an existing gases plant at Bayport, Tex. All three projects were scheduled onstream by fall 1977. Big Three also announced plans to build an air separation plant at Etiwanda, Calif., to supply liquid nitrogen, oxygen, and argon for the industrial gas market of southern California, and oxygen for steel production.[27]

Liquid Air, Inc., announced plans to add nearly 400 tons per day of liquid nitrogen, oxygen, and argon capacity at their Union City, Calif., and Houston, Tex., plants. The $8 million project was scheduled for completion in late 1977.[28]

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[16]Work cited in footnote 13.
Chemical Week. Fertile Field for Fertilizer Savings. V. 118, No. 21, May 26, 1976, p. 31.
[17]Nitrogen. New Plants and Projects. No. 101, May/June 1976, p. 13.
[18]———. New Plants and Projects. No. 104, November/December 1976, p. 14.
[19]Chemical Marketing Reporter. Hercules Closes Sale of Nitrogen Products Unit With Fertilizer Company. V. 210, No. 5, Oct. 11, 1976, pp. 7, 27.
[20]Work cited in footnote 13.
[21]Chemical Marketing Reporter. Air Products Starts Up New Gas Plant in Illinois. V. 209, No. 3, Jan. 19, 1976, pp. 4, 22.
———. Liquid Gas Plant in Ga. Running for Air Products. V. 210, No. 5, Aug. 2, 1976, pp. 7, 19.
[22]———. Air Products Planning Gas Plant in Oklahoma. V. 209, No. 11, Mar. 15, 1976, p. 4.
———. Air Products Slates Industrial Gas Plants. V. 209, No. 24, June 14, 1976, p. 4.
[23]Chemical Week. Air Products to Supply Gas for Syngas Co. V. 119, No. 13, Sept. 29, 1976, p. 11.
[24]Chemical & Engineering News. Checkoff. New Construction. V. 54, No. 43, Oct. 18, 1976, p. 19.
[25]Chemical Marketing Reporter. Union Carbide Planning Tacoma Liquid Gas Plant. V. 209, No. 12, Mar. 22, 1976, pp. 3, 35.
[26]———. Union Carbide Starts Indiana Oxygen Facility. V. 210, No. 13, Sept. 27, 1976, pp. 4, 77.
[27]Chemical & Engineering News. Checkoff. New Plants. V. 54, No. 30, July 19, 1976, p. 10.
[28]———. Checkoff. New Plants. V. 54, No. 29, July 12, 1976, p. 12.

Table 2.—Nitrogen production in the United States

(Thousand short tons of contained nitrogen)

	1972	1973	1974	1975	1976[p]
Anhydrous ammonia, synthetic plants [1]	[r]12,476	12,508	[r]12,939	13,504	13,748
Ammonium compounds, coking plants:					
Ammonia liquor	11	6	6	5	4
Ammonium sulfate	[r]129	127	116	108	111
Ammonium phosphates	(2)	(2)	(2)	(2)	(2)
Total	[r]12,616	12,641	[r]13,061	13,617	13,863
Elemental nitrogen [1]	7,011	[r]8,229	[r]8,814	9,142	10,503

[p]Preliminary. [r]Revised.
[1]Current Industrial Reports, U.S. Department of Commerce, Bureau of the Census.
[2]Included with ammonium sulfate to avoid disclosing individual company confidential data.

Table 3.—Major nitrogen compounds produced in the United States

(Thousand short tons, gross weight)

Compound	1975	1976[p]
Acrylonitrile	607	759
Ammonium nitrate	7,088	7,186
Ammonium sulfate[1]	2,617	2,532
Ammonium phosphates	7,620	8,988
Nitric acid	7,527	7,892
Urea	3,565	3,928

[p]Preliminary.
[1]Includes ammonium sulfate from coking plants.

Sources: Bureau of the Census and International Trade Commission.

Table 4.—Domestic producers of urea

(Thousand short tons per year of urea)

Company	Location	Capacity
Agrico Chemical Co. - Williams	Blytheville, Ark	340
Do	Donaldsonville, La	200
Do	Verdigris, Okla	250
Agway, Inc	Olean, N.Y	63
Air Products & Chemicals, Inc	Pace Junction, Fla	23
Allied Chemical Corp	LaPlatte, Nebr	125
Do	Geismar, La	230
Do	South Point, Ohio	125
American Cyanamid Co	Fortier, La	145
Atlas Chemical Industries, Inc	Joplin, Mo	70
Beker Industries, Inc	Carlsbad, N.Mex	175
Borden Chemical Co	Geismar, La	215
CF Industries, Inc	Donaldsonville, La	375
Do	Fremont, Nebr	20
Collier Carbon & Chemical Corp	Kenai, Alaska	340
Do	Brea, Calif	120
Columbia Nitrogen Corp	Augusta, Ga	30
E. I. duPont de Nemours & Co	Belle, W. Va	60
Farmers Chemical Association - CF Industries, Inc	Tunis, N.C	165
Do	Tyner, Tenn	45
Farmland Industries, Inc	Fort Dodge, Iowa	70
Do	Lawrence, Kans	266
Gardinier, Inc	Helena, Ark	75
Goodpasture, Inc	Dimmitt, Tex	24
W. R. Grace & Co	Woodstock, Tenn	350
Hawkeye Chemical Co	Clinton, Iowa	61
Hercules, Inc	Hercules, Calif	45
Do	Louisiana, Mo	95
Kaiser Agricultural Chemicals Co	Savannah, Ga	132
Mississippi Chemical Corp	Yazoo City, Miss	153
Nipak, Inc	Pryor, Okla	180
Do	Kerens, Tex	86

Table 4.—Domestic producers of urea —Continued

(Thousand short tons per year of urea)

Company	Location	Capacity
N - Ren Corp. (Cherokee Nitrogen, Inc.)	Pryor, Okla	27
N - Ren Corp. (Farmers National Chemical Co.)	Plainview, Tex	45
N - Ren Corp. (St. Paul Ammonia Products Co.)	East Dubuque, Ill	85
Olin Corp	Lake Charles, La	160
Phillips Pacific Chemical Co	Kennewick, Wash	43
Phillips Petroleum Co	Beatrice, Nebr	56
Premier Petrochemical Co	Pasadena, Tex	103
Reichhold Chemicals, Inc	St. Helens, Oreg	132
J. R. Simplot Co	Pocatello, Idaho	18
Swift Chemical Co	Beaumont, Tex	49
Tennessee Valley Authority	Muscle Shoals, Ala	66
Terra Chemicals International, Inc	Port Neal, Iowa	170
Triad Chemical Co	Donaldsonville, La	420
U.S.S. Agri - Chemicals, Inc	Cherokee, Ala	25
Valley Nitrogen Producers, Inc	El Centro, Calif	155
Do	Helm, Calif	29
Vistron Corp	Lima, Ohio	238
Wycon Chemical Co	Cheyenne, Wyo	50
Total		6,524

Source: World Fertilizer Capacity, Urea. (Distribution Economics Section, Tennessee Valley Authority, Muscle Shoals, Ala., Oct. 17, 1977).

CONSUMPTION AND USES

Consumption of fixed nitrogen in the United States reached 13.9 million tons in 1976, an increase of 7%. Excellent spring weather and low prices created strong demand for nitrogenous fertilizers. Demand for other nitrogen-containing chemicals, such as acrylonitrile, increased also, reflecting the economic recovery from the slump in 1975. Elemental nitrogen consumption is assumed to be equal to production, since no statistics are collected on stocks, and international trade is negligible.

The primary use of fixed nitrogen was in fertilizers, which accounted for approximately three-fourths of production. Other uses included explosives, resins, fibers, plastics, and animal feeds. The two principal uses of elemental nitrogen were as a gas to exclude or purge air from such industrial processes as steelmaking, electronics, chemical manufacture, and glassmaking, and as a liquid to provide low temperatures in food processing and scientific applications.

PRICES

Spot market prices for anhydrous ammonia were well below list at the beginning of the year because of buyer resistance and growing inventories. Published list prices of agricultural-grade urea and diammonium phosphate were lowered substantially during the year. Prices paid by U.S. farmers for all nitrogenous fertilizers in 1976 continued to decrease from the peak attained in early 1975. The cost of anhydrous ammonia, ammonium nitrate, and urea at the farm level dropped an average of 29% from April 1975 to April 1976.[29]

The average price of elemental nitrogen as pipeline gas was $11.78 per ton in 1976, an increase of 6%. The price of elemental bulk liquid nitrogen dropped 1% to $57.49 per ton.[30] Airco, Inc., Air Products & Chemicals, Inc., and Union Carbide Corp. announced price increases of 4% to 10% for liquid, bulk, and compressed nitrogen and other industrial gases effective November and December 1976.[31]

[29]U.S. Economic Research Service, Department of Agriculture. 1977 Fertilizer Situation, January 1977, pp. 8-9.

[30]Bureau of the Census, U.S. Department of Commerce. Industrial Gases. Current Industrial Reports, August 1977.

[31]Chemical Week. Air Products Follows Gas Price Increases. V. 119, No. 21, Nov. 24, 1976, p. 31.

Table 5.—Price quotations for major nitrogen compounds in 1976

(Per short ton)

Compound	January	December
Ammonium nitrate, domestic, fertilizer-grade, 33.5% nitrogen, bulk, delivered	$91-$115	$91-$115
Ammonium sulfate, standard-grade, commercial, bulk, f.o.b. works	60	60
Anhydrous ammonia, fertilizer, wholesale, tanks, delivered east of Rockies, except east coast	180-190	180-190
Aqueous ammonia, 29.4% NH_3, anhydrous basis, tanks, freight equalized east of Rockies	165-180	165-180
Sodium nitrate, domestic, agricultural, bulk, carlots, f.o.b. works	139	139
Bags, carlots, f.o.b. works	130	150
Sodium nitrate, imported, commercial, bulk, carlots, f.o.b. Atlantic and Gulf warehouses	112	118
100-pound bags, carlot, same basis	124	130
Sodium nitrate, imported, agricultural, bulk, carlots, Atlantic and Gulf warehouses	--	100
Urea:		
Industrial, 46% nitrogen, bulk, 50-ton carlots, delivered East	160-175	160-175
Agricultural, 46% nitrogen, bulk, same basis	160-175	130-140
Agricultural, 45% nitrogen, bulk, 50-ton carlots, delivered East	160-175	120-130
Diammonium phosphate, fertilizer grade, 18-46-0, bulk, carlots, f.o.b. Florida works	135	110-125

Source: Chemical Marketing Reporter.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds

(Thousand short tons and thousand dollars)

Compounds	1975			1976		
	Gross weight	Nitrogen content[e]	Value	Gross weight	Nitrogen content[e]	Value
EXPORTS						
Industrial chemicals: Anhydrous ammonia and chemical grade aqua (ammonia content)	[r]82	[r]67	[r]13,005	133	109	11,167
Fertilizer materials:						
Ammonium nitrate	46	15	6,141	12	4	1,444
Ammonium phosphates	[r]2,685	[r]483	[r]575,268	2,823	508	309,192
Ammonium sulfate	[r]726	[r]150	[r]48,297	644	133	20,066
Anhydrous ammonia and aqua (ammonia content)	[r]271	[r]222	[r]49,657	307	252	29,205
Nitrogenous chemical materials n.e.c	[r]43	[r]13	[r]3,975	19	6	2,635
Sodium nitrate	2	(1)	164	2	(1)	183
Urea	557	253	[r]122,908	532	242	45,241
Mixed chemical fertilizers	324	32	40,695	242	24	30,284
Total	[r]4,736	[r]1,235	[r]860,110	4,714	1,278	449,417
IMPORTS						
Industrial chemicals: Ammonium nitrate	3	1	451	3	1	356
Fertilizer materials:						
Ammonium nitrate	245	82	24,881	312	105	24,146
Ammonium nitrate-limestone mixtures	66	14	8,971	29	6	1,439
Diammonium phosphates	92	16	14,112	142	26	18,642
Other ammonium phosphates	211	38	36,528	70	13	8,294
Ammonium sulfate	219	45	21,357	566	117	23,549
Calcium cyanamide or lime nitrogen	57	12	338	38	8	447
Calcium nitrate	95	15	7,099	64	10	3,875
Nitrogen solutions	117	35	11,666	302	91	21,797
Anhydrous ammonia	807	662	123,932	730	599	70,836
Potassium nitrate or saltpeter, crude	36	4	7,016	14	2	2,297
Potassium nitrate, sodium nitrate mixtures	25	4	4,388	40	6	5,345
Sodium nitrate	139	22	19,100	103	16	8,143
Urea	654	298	87,899	842	383	84,674
Nitrogenous fertilizers n.s.p.f	134	27	14,407	100	20	9,246
Mixed chemical fertilizers	213	21	33,389	112	11	13,728
Total	3,113	1,296	415,534	3,467	1,414	296,814

[e]Estimate. [r]Revised.
[1]Less than 1/2 unit.

FOREIGN TRADE

Increased U.S. exports of ammonia and ammonium phosphates offset the reduced export levels of other nitrogenous fertilizers, as exports of contained nitrogen rose 3%. Substantial gains in imported urea, ammonium sulfate, and nitrogen solutions resulted in a 9% gain for fixed nitrogen imports. In terms of nitrogen content, the United States was a net importer of fixed nitrogen for the third consecutive year. Net imports amounted to 136,000 tons of nutrient, compared with 61,000 tons in 1975.

WORLD REVIEW

Large expansions of ammonia capacity have been scheduled in eastern Europe, the U.S.S.R., and a number of developing countries. Implementation of these projects could make inroads into the markets of traditional exporters of nitrogenous fertilizers. In addition, many importing nations have moved closer to self-sufficiency. Producers in Japan and western Europe lowered their output because of reductions in domestic purchases and exports. France and West Germany voiced disapproval of an influx of certain low-priced, nitrogenous fertilizers from eastern Europe. World fertilizer prices have declined sharply from the levels attained in spring 1975.

Albania.—A new urea plant with a capacity of 40,000 tons per year of contained nitrogen was completed at Fieri.[32]

Belgium.—Ste. Carbochimique, S.A. commissioned a new 236,000-ton-per-year nitric acid plant at Tertre in September.[33]

Brazil.—Pullman Kellogg was awarded a contract by Petrobras for the technology and design engineering of two 1,070-ton-per-day ammonia plants to be built at Laranjeiras and Norte Fluminense. The plants will be associated with two 1,200-ton-per-day urea units of Mitsui Toatsu technology.[34] A West German consortium received a contract for the construction of a 1,320-ton-per-day ammonia plant and a 1,650-ton-per-day urea unit at Araucaria. The facility will utilize heavy petroleum fractions as feedstock, and was scheduled for startup in 1978. Similar complexes were being planned at Paulinia and Aracaja.[35] The two 1,100-ton-per-day ammonia plants under construction at Camaçari were scheduled to come onstream at yearend 1977.[36]

Bulgaria.—A 200,000-ton-per-year ammonia plant and a 300,000-ton-per-year ammonium sulfate unit, both designed and constructed by Humphreys & Glasgow Ltd., started up at the Povelianovo Chemical Combine at Varna.[37]

Cameroon.—Ste. Cameroonaise des Engrais started up a 55,000-ton-per-year ammonium sulfate plant and a 30,000-ton-per-year complex fertilizer plant at Douala.[38]

Canada.—Canadian Fertilizers Ltd. brought the first of two 396,000-ton-per-year ammonia plants and a 495,000-ton-per-year urea unit onstream at Medicine Hat, Alberta, in the summer of 1976. Although the company announced in December that it had deferred the remainder of the project, financing has since been completed and construction was scheduled to proceed. The second plant was scheduled to come onstream in 1977. Production from both ammonia plants will be used for direct application and conversion to granular urea. The material will be earmarked for consumption in Canada and the United States.[39]

Pan Canadian Petroleum Ltd. announced at yearend that it will not proceed with an ammonia plant at Brooks, Alberta. Pan Canadian's partner in the venture, Tyler Corp., of Dallas, Tex., withdrew several months before. Sherritt Gordon Mines has also decided to shelve plans to expand its ammonia-urea complex at Fort Saskatchewan, Alberta.[40]

Genstar Chemical Co. commissioned a $9.5 million expansion of its nitric acid and

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[32]Nitrogen. New Plants and Projects. No. 103, September/October 1976, p. 13.
[33]Work cited in footnote 32.
[34]European Chemical News. Kellogg Wins Brazilian Ammonia Plant. V. 29, No. 767, Dec. 31, 1976, p. 20.
[35]Nitrogen. New Plants and Projects. No. 100, March/April 1976, p. 17.
[36]Chemical Age. Kellogg Ammonia Contract. V. 113, No. 2992, Nov. 19, 1976, p. 16.
[37]Nitrogen. New Plants and Projects. No. 99, January/February 1976, p. 10.
[38]Work cited in footnote 18.
[39]Chemical Marketing Reporter. Ammonia Unit Opens in Alberta; Second To Be Running in '77. V. 209, No. 13, June 21, 1976, pp. 7, 27.
European Chemical News. New Projects. In Brief. V. 30, No. 769, Jan. 14, 1977, p. 29.
[40]Fertilizer International. In Brief. No. 80, February 1976, p. 10.
European Chemical News. Alberta Plants Shelved. V. 29, No. 767, Dec. 31, 1976, p. 21.

ammonium nitrate facilities at Maitland, Ontario.[41]

Union Carbide Canada announced plans for a 260-ton-per-day expansion of its air separation plants at Oakville, Ontario.[42] Air Products Ltd. scheduled the construction of an industrial gases plant with capacity of 400,000 tons per year at Nanticoke, Ontario. The plant will also produce 300 tons of liquid nitrogen, oxygen, and argon daily.[43] Liquid Air Corp. of North America began construction of a new air separation unit, the fourth at its Hamilton, Ontario, complex. The $15 million plant will supply an additional 250 tons of nitrogen and 600 tons of oxygen daily to Dominion Foundries & Steel Ltd. when it comes onstream early in 1979. Total daily production at the complex will then exceed 1,500 tons of nitrogen and 2,800 tons of oxygen[44]

Chile.—Petroquimica Chilena awarded a contract to Snamprogetti for a 1,485-ton-per-day ammonia plant and a 2,200- ton-per-day urea unit. The complex will be located by the Straits of Magellan in order to use the natural gas reserves in the area. A large percentage of the output from the facility is destined for export, primarily to Brazil and Argentina.[45]

China, People's Republic of.—Four ammonia-urea facilities went onstream in the provinces of Heilongkiang, Liaoning, Szechwan, and Hopei. Each facility included a 1,100-ton-per-day ammonia plant and a 1,780-ton-per-day urea unit of Kellogg design.[46] Although the country remains a large importer of nitrogenous fertilizers, imports have been steadily declining and domestic production has been increasing. Small-scale plants on the local level account for about one-half of total production. The nation should be self-sufficient in urea by the end of the decade.[47]

Denmark.—A new 165,000-ton-per-year nitric acid plant was commissioned by Superfos A/S at Fredericia.[48]

Egypt.—Three nitric acid plants with a combined capacity of 770 tons per day were brought onstream at Talkha. A fourth unit was scheduled for completion in 1978. In September nitrogenous fertilizer production began at the Talkha complex. Three Arab funds will provide financing for the second phase of the Talkha project, which includes a 359,000-ton-per-year ammonia plant and a 288,000-ton-per-year urea unit, due for completion in 1978. Feedstock is natural gas from the Abu Madi field in northern Egypt.[49]

France.—Friedrich Uhde GmbH was awarded a contract to build a 550-ton-per-day nitric acid plant at Lievin for Gardinier.[50] Air Products & Chemicals, Inc., began producing nitrogen, oxygen, and argon at a new 300-ton-per-day air separation plant at Beauvais.[51] An air separation plant with a capacity of 220 tons per day of liquid nitrogen, oxygen, and argon will be constructed near Lyons by Airgaz. Commissioning was slated for mid-1978.[52]

Germany, East.—The third 385,000-ton-per-year urea plant came onstream at Piesteritz.[53]

India.—The Fertilizer Association of India stated that the country must build five more nitrogenous fertilizer plants in addition to projects currently underway and the four presently approved in principle to bridge the gap between production and consumption by 1983-84.[54] The Fertilizer Corp. of India Ltd. commissioned a new naphtha-fed, ammonia-urea facility at Barauni in July. The capacities of the units are 220,000 tons of ammonia and 363,000 tons of urea per year.[55] Mangalore Chemicals and Fertilizers Ltd. commissioned a new urea plant at Mangalore with a capacity of 176,000 tons per year of nutrient.[56] Snamprogetti of Italy was awarded a contract by Gujarat State Fertilizers Co. Ltd. for a 1,980-ton-per-day urea plant to be built at Baroda.[57] Two ammonia-urea complexes

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[41]European Chemical News. Market Report. In Brief. V. 29, No. 756, Oct. 8, 1976, p. 14.

[42]Chemical & Engineering News. Checkoff. New Plants. V. 54, No. 29, July 12, 1976, p. 13.

[43]Page 11 of work cited in footnote 37.

[44]Chemical Marketing Reporter. Oxygen-Nitrogen Plant for Canada Steel Firm. V. 210, No. 6, Aug. 9, 1976, pp. 4, 11.

[45]Fertilizer International. Chile—Plans for Urea Production. No. 81, March 1976, p. 4.

[46]Chemical & Engineering News. Concentrates. International. V. 54, No. 45, Nov. 1, 1976, p. 7.

European Chemical News. Great Leap Forward in Chinese Urea Production. V. 29, No. 760, Nov. 5, 1976, p. 16.

[47]Fertilizer International. China: Self-Sufficiency in Agriculture a Priority, in Fertilizer Production—a Necessity. No. 83, May 1976, pp. 14, 15, 24.

[48]Work cited in footnote 32.

[49]European Chemical News. Egypt Opens First Talkha Fertilizer Plant. V. 29, No. 755, Oct. 1, 1976, p. 7.

Page 15 of work cited in footnote 32.

[50]Chemical Marketing Reporter. Friedrich Uhde to Build French Nitric Acid Unit. V. 209, No. 1, Jan. 5, 1976, p. 4.

[51]———. Air Products Unit Opens. V. 209, No. 13, Mar. 29, 1976, p. 4.

[52]European Chemical News. Airgaz Goes for Lyon Gases Project. V. 29, No. 758, Oct. 22, 1976, p. 46.

[53]Page 15 of work cited in footnote 35.

[54]European Chemical News. New Projects. In Brief. V. 29, No. 755, Oct. 1, 1976, p. 36.

[55]———. FCI Starts Barauni Ammonia/Urea Plant. V. 29, No. 746, July 23, 1976, p. 12.

[56]———. New Indian Urea Plant. V.28, No.732, Apr. 16, 1976, p.33.

[57]Chemical Marketing Reporter. Snamprogetti Contracts for India Urea Facility. V. 210, No. 16, Oct. 18, 1976, p. 4.

with daily capacities of 990 tons of ammonia and 1,700 tons of urea were scheduled onstream in 1978 at Bhatinda and Panipat.[58]

Indonesia.—Kellogg Overseas Corp. was named managing director for a grass-roots, ammonia-urea facility at Cikampek, West Java. The complex will consist of a 1,100-ton-per-day ammonia plant and a 1,900-ton-per-day urea unit. A major portion of the $200 million project will be financed by the Government of Iran. Plans to build the world's first floating fertilizer plant near gasfields off the coast of Kalimantan Province have been scrapped. A new plan calls for locating the plant on land, with daily capacities of 1,650 tons of ammonia and 1,100 tons of urea. The future of a proposed ammonia-urea facility at Aceh, North Sumatra, is uncertain. As the country's urea capacity climbs beyond 2 million tons per year, an exportable surplus should become available.[59]

Iran.—Construction of a new fertilizer complex using natural gas feedstock began at Shiraz for the Iran Fertilizer Co. The facilities were scheduled onstream in 1978 and will have annual capacities of 359,000 tons of ammonia, 248,000 tons of nutrient as urea, 76,000 tons of nutrient as ammonium nitrate, and 218,000 tons of nitric acid.[60]

Iraq.—The expansion at the Basrah fertilizer complex was completed by Mitsubishi Heavy Industries. The plant has a daily capacity of 880 tons of ammonia and 1,430 tons of urea. By 1982 ammonia capacity is scheduled to reach 1.5 million tons per year. At that point, Iraq's ammonia production could account for about one-third of the Middle East total.[61]

Italy.—Breda Cantiere Navale shipyards received a contract from Sudimport, the foreign trade organization of the U.S.S.R., to build three ammonia tankers.[62]

Japan.—A 91,000-ton-per-year nitric acid plant was completed by Mitsubishi Heavy Industries at Kurosaki.[63] Japanese urea exports declined sharply in 1976. As a result, ammonia and urea production have been running well below capacity. The industry, which is heavily dependent upon exports, urged the Government to offer tied loans and fertilizer supply arrangements as part of its economic aid program for Southeast Asian countries.[64]

Korea, North.—A $64 million complex was completed by West German and Austrian contractors at Nam Hung, the first large-scale chemical facility built in North Korea by Western contractors. Annual plant capacities were listed as 272,000 tons of ammonia and 400,000 tons of urea.[65]

Korea, Republic of.—Air Products & Chemicals, Inc., received a $20 million contract for design and construction of two 850-ton-per-day nitrogen, oxygen, argon plants for the Pohang Iron & Steel Co. Both plants were scheduled for completion in late 1978.[66] Yong-Nam Chemical Co. Ltd. completed an expansion project at its Ulsan complex. Total capacities were increased to more than 110,000 tons per year of ammonia and 132,000 tons per year of urea.[67]

Libya.—Libyan National Oil awarded a contract to Foster Wheeler Italiana for the construction of the country's first urea plant at Marsa el Brega by 1979. Ammonia feedstock for the 1,100-ton- per-day unit will be supplied by National Oil's adjacent plant which was due onstream in 1977.[68]

Mexico.—Guanos y Fertilizantes S.A. planned to construct two new urea plants. One of the units will be built at Coatzacoalcos with a capacity of 495,000 tons per year, and the other will be located near Salamanca with a capacity of 330,000 tons per year. The new production has been designated for both domestic consumption and export markets, since completion of the plants should result in self-sufficiency for the country in nitrogenous fertilizers.[69]

Poland.—Creusot-Loire Enterprises of France has contracted for the installation of a fertilizer complex at Police. The complex will comprise two 825-ton-per-day ammonia

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[58]Chemical Age. Veba Ammonia Study. V. 113, No. 2979-2980, Aug. 20-27, 1976, p. 2.

[59]Chemical Marketing Reporter. Indonesia Fertilizer Job To Be Run by Kellogg; First Such Unit on Java. V. 209, No. 9, Mar. 1, 1976, p. 80.

Chemical Week. Indonesia Aims at Fertilizer Self-Sufficiency. V. 119, No. 10, Sept. 8, 1976, p. 51.

———. Canadian Potash Will Be "Competitive." V. 119, No. 13, pp. 26-27.

[60]Page 15 of work cited in footnote 18.

[61]European Chemical News. Iraq Ammonia/Urea Expansion Completed. V. 29, No. 764, Dec. 3, 1976, p. 20.

Fertilizer International. Iraq at the Center of Middle East Expansion Plans. No. 89, November 1976, p. 10.

[62]Chemical Age. Italy To Build Soviet Ships. V. 113, No. 2990, Nov. 5, 1976, p. 6.

[63]Page 15 of work cited in footnote 18.

[64]European Chemical News. Japan Wants Fertilizer Aids. V. 29, No. 752, Sept. 10, 1976, p. 6.

[65]Chemical Marketing Reporter. Fertilizer Complex Built by Uhde in North Korea. V. 210, No. 15, Oct. 11, 1976, p. 5.

[66]———. Air Products Awarded Contract for Gas Unit. V. 209, No. 16, Apr. 19, 1976, p. 7.

[67]Page 13 of work cited in footnote 37.

[68]European Chemical News. Foster Wheeler Wins Libyan Urea Order. V. 29, No. 762, Nov. 19, 1976, p. 59.

[69]Chemical Marketing Reporter. Guanomex in Expansion of Fertilizers, Parathion. V. 209, No. 2, Jan. 12, 1976, p. 7.

Fertilizer International. Changing Roles in Mexico. No. 90, December 1976, p. 6.

plants, one 1,320-ton-per-day urea unit and mixed fertilizer facilities, with a projected startup date of late 1979.[70] Krupp Chemieanlagen of West Germany gained a contract for the construction of two coal gasification plants at a coal-based chemicals complex planned for Katowice. The complex will include a 550,000-ton-per-year ammonia plant and an 880,000-ton-per-year urea unit.[71]

Qatar.—Qatar Fertilizer Co. awarded a contract for the construction of a 1,000-ton-per-day ammonia plant at Umm Said, to be associated with a 1,100-ton-per-day urea plant. The complex was scheduled onstream in 1978.[72]

Spain.—Union Explosivos Rio Tinto commenced production at a 990-ton-per-day ammonia plant at Huelva. The plant uses naphtha as feedstock.[73] Local opposition to the construction of an ammonia plant by the fertilizer group Sefanitro at Bilbao led authorities to revoke the construction permit. Site preparation and equipment procurement for the plant were well advanced at the time. Sefanitro was seeking to form a partnership with one of several companies that would provide a new site.[74]

Syria.—Creusot-Loire Enterprises of France was awarded a turnkey contract by Unichem for a refinery and fertilizer complex at Homs. Naphtha from the refinery will be used as feedstock for a 363,000-ton-per-year ammonia plant with a downstream 400,000-ton-per-year urea unit.[75]

Turkey.—Kellogg International Corp. was awarded a contract by Azot Sanayii for a 314,000-ton-per-year ammonia plant at Gemlik. Part of the output from this naphtha-fed plant was slated for use in a new 172,000-ton-per-year ammonium nitrate unit.[76] Friedrich Uhde GmbH received a contract for construction of an 82,500-ton-per-year ammonium sulfate plant and other units at Bandirma by late 1978.[77]

U.S.S.R.—Toyo Engineering Corp. of Japan reached agreement with the U.S.S.R. to supply five more 1,500-ton-per-day ammonia plants using Pullman Kellogg technology at Kiev, Minsk, Kharkov, Moscow, and Perm. These plants are in addition to the deal concluded in 1975 for four identical plants.[78] Montedison of Italy contracted with Techmashimport to furnish two 1,650-ton-per-day urea plants at Kemerovo and Berezniki. Ammonia feedstocks will come from plants being constructed at the sites.[79] Technoexport Foreign Trade Co. Ltd. of Czechoslovakia agreed to construct and deliver three urea production lines, each with a capacity of 177,000 tons per year. Destinations are Grodno, Dneprodzherzhinsk, and Cherkassy in 1977-78.[80] New ammonium nitrate facilities came onstream at Berezniki, increasing downstream product capacity by 110,000 tons per year of contained nitrogen. Installed anhydrous ammonia capacity at the Severodonetsk complex reached 1.4 million tons with the completion of another 495,000-ton-per-year plant. A new urea plant was commissioned at Salavat bringing total urea capacity there to 540,000 tons per year.[81]

The first specific contract under the 1973 fertilizer agreement between Occidental Petroleum Corp. and the U.S.S.R. was signed in late November at Moscow. The contract called for the U.S.S.R. to supply Occidental with 3.5 million tons of ammonia over a 10-year period beginning in 1978. The company has been assisting the Soviets in the construction of ammonia pipeline and port facilities and arranging for new ammonia plants in the Soviet Union. Occidental is scheduled to deliver superphosphoric acid to the U.S.S.R. and receive ammonia, urea, and potash. Separate contracts still remain to be signed for the other components of the agreement.[82]

United Kingdom.—British Oxygen Corp. announced plans to expand production of industrial gases at its Brinsworth site near Rotherham. The new unit will produce 132 tons of nitrogen, 132 tons of oxygen, and 5 tons of argon daily. Construction was scheduled to start in January 1977 with an onstream target date of early 1979.[83] The Secretary of State for Scotland granted

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[70]Chemical Marketing Reporter. Fertilizer Plants Slated To Be Built for Poland. V. 209, No. 2, Jan. 12, 1976, p. 7.

[71]Fertilizer International. Plant & Project News. No. 85, July 1976, p. 10.

[72]European Chemical News. New Projects. In Brief. V. 29, No. 767, Dec. 31, 1976, p. 21.

[73]Chemical Age. Ammonia Plant Starts in Spain. V. 113, No. 2984, Sept. 24, 1976, p. 16.

[74]European Chemical News. Sefanitro Nears Decision on Joint Ammonia Project. V. 29, No. 755, Oct. 1, 1976, p. 35.

[75]Page 13 of work cited in footnote 37.

[76]Page 14 of work cited in footnote 35.

[77]European Chemical News. Uhde Wins Two Fertilizer Contracts in Turkey. V. 29, No. 751, Sept. 3, 1976, p. 46.

[78]Fertilizer International. Four More Ammonia Plants for the U.S.S.R. No. 79, January 1976, p. 1.

Chemical Marketing Reporter. Kellogg Ammonia Unit. V. 210, No. 25, Dec. 20, 1976, p. 16.

[79]Fertilizer International. Plant & Project News. No. 86, August 1976, p. 10.

[80]Work cited in footnote 18.

[81]Page 16 of work cited in footnote 35.

[82]Chemical Week. Oxy Signs Soviet Pact. V. 119, No. 22, Dec. 1, 1976, p. 15.

European Chemical News. Oxy Signs First U.S.S.R. Ammonia Contract. V. 29, No. 764, Dec. 3, 1976, p. 4.

[83]Chemical Age. Gas Expansion. V. 113, No. 2992, Nov. 19, 1976, p. 4.

approval for a Scandinavian chemicals group, Scanitro, to construct a 350,000-ton-per-year ammonia plant at Peterhead, Scotland. The $100 million facility will utilize natural gas feedstock from the North Sea. The plan must still receive the approval of local authorities. Scottish Agricultural Industries has contracted for an 88,000-ton-per-year prilled ammonium nitrate plant at Leith. The plant was scheduled onstream in 1978.[84]

Zambia.—Nitrogen Chemicals of Zambia was expanding its nitrogenous fertilizer complex at Kafue. The new coal-based ammonia plant will have a capacity of 85,000 tons per year, and was due onstream by July 1977.[85]

[84]Chemical Marketing Reporter. Scanitro Gets Okay for Ammonia Project. V. 209, No. 14, Apr. 5, 1976, pp. 5, 16.
European Chemical News. CJB Fertilizer Order. V. 29, No. 755, Oct. 1, 1976, p. 35.

[85]Page 12 of work cited in footnote 37.

Table 7.—Fertilizer nitrogen compounds: World production and consumption for years ended June 30, by country

(Thousand short tons of contained nitrogen)

Country	Production			Consumption		
	1973-74	1974-75	1975-76[p]	1973-74	1974-75	1975-76[p]
North America:						
Canada	885	[e]987	1,010	565	[e]586	619
Costa Rica[e]	30	33	33	[1]37	[r] [1]37	[1]37
Cuba	22	51	90	[1]144	[1]153	[1]172
Dominican Republic	--	--	--	45	51	45
El Salvador[e]	8	8	6	75	69	72
Guatemala[e]	3	6	6	38	46	33
Jamaica[e]	3	3	3	[1]12	[1]14	[1]10
Mexico	414	517	640	[r]580	721	918
Netherlands Antilles[e]	7	23	7	--	--	--
Nicaragua[e]	--	--	--	39	24	18
Panama	--	--	--	13	15	15
Trinidad and Tobago[e]	74	100	63	[1]8	[1]6	[1]5
United States (includes Puerto Rico)	10,095	9,341	10,210	[r]9,146	8,608	10,345
South America:						
Argentina	32	[e]28	20	48	[e]46	31
Brazil[1]	126	166	177	383	429	452
Chile[1]	118	125	127	65	57	43
Colombia[1]	95	[e]99	110	170	[e]140	144
Ecuador[e]	2	2	2	32	[r]22	22
Peru	23	22	39	89	125	90
Venezuela[e] [1]	7	53	55	45	64	71
Europe:						
Albania[e] [1]	40	40	40	40	40	40
Austria	254	249	261	146	138	134
Belgium-Luxembourg	721	707	673	198	204	201
Bulgaria[1]	572	654	741	362	363	419
Czechoslovakia	[1]456	[1]533	[1]579	455	472	563
Denmark[2]	[r]70	90	88	402	331	374
Finland	269	278	223	228	250	220
France	1,810	1,867	1,493	2,021	1,714	1,883
Germany, East[1]	453	481	594	734	740	747
Germany, West	1,624	1,735	1,388	1,213	1,324	1,354
Greece	290	291	318	269	277	303
Hungary[1]	468	[e]459	499	543	608	591
Iceland[1]	11	8	10	16	15	16
Ireland	[e]104	[e]107	110	144	147	168
Italy	[e]1,245	1,247	1,102	741	741	798
Netherlands	[e]1,324	1,395	1,271	[e]454	480	499
Norway	490	430	393	94	106	108
Poland[1]	1,505	1,607	1,689	1,184	1,260	1,349
Portugal[e]	181	211	224	141	140	155
Romania[1]	941	1,080	1,424	487	540	869
Spain[1]	841	[e]796	909	803	787	841
Sweden[3]	197	194	187	[4]290	[4]259	[4]283
Switzerland	29	32	33	46	42	47
U.S.S.R.[1]	[r]7,947	8,605	9,331	[r]6,861	7,381	8,110
United Kingdom[3]	833	1,099	1,163	964	1,022	1,151
Yugoslavia[1]	386	409	394	374	388	396
Africa:						
Algeria[e]	57	87	67	[1]103	[r] [1]72	[1]69
Egypt	[1]56	[e] [1]110	[1]166	[5]395	[e] [5]397	[e]457
Ivory Coast[1]	5	7	5	9	9	12
Kenya	--	--	--	22	21	23
Mauritius[e]	--	1	4	12	10	11
Morocco[1]	16	[e]12	21	[e]69	[e]68	70
Mozambique	[e]9	[e]3	3	[e]10	4	4
Nigeria	--	--	--	[e]5	[e]15	33

Table 7.—Fertilizer nitrogen compounds: World production and consumption for years ended June 30, by country —Continued

(Thousand short tons of contained nitrogen)

Country	Production			Consumption		
	1973-74	1974-75	1975-76[p]	1973-74	1974-75	1975-76[p]
Africa: —Continued						
Rhodesia, Southern[e]	66	72	72	77	r77	83
Senegal	10	e6	10	8	e10	11
South Africa, Republic of[1]	283	r e299	331	e255	254	314
Sudan	--	--	--	60	66	105
Tanzania[1]	2	4	4	12	15	16
Tunisia	--	--	--	21	26	20
Zambia	5	8	6	e26	e40	e46
Asia:						
Afghanistan	--	21	43	20	27	31
Bangladesh	143	36	144	140	91	166
Burma	r41	48	52	40	42	39
China, People's Republic of[6]	2,830	3,207	3,404	4,191	4,256	4,765
India	1,157	1,308	1,662	2,016	1,947	2,239
Indonesia[e]	94	183	229	386	380	377
Iran	144	144	139	214	208	214
Iraq	31	36	27	22	30	28
Israel	35	43	50	33	36	40
Japan	e2,357	e2,580	1,716	905	761	703
Korea, North[e 1]	265	276	287	269	278	291
Korea, Republic of[1]	493	566	596	453	493	516
Kuwait	320	304	285	--	--	--
Lebanon[1]	--	--	1	43	21	8
Malaysia	751	e 741	737	e124	e76	79
Pakistan	331	343	349	r364	396	487
Philippines[1]	59	59	63	167	196	146
Qatar[e]	15	61	96	--	--	--
Saudi Arabia	67	e89	110	e4	6	6
Sri Lanka	--	--	--	56	e82	42
Syria	10	14	26	37	40	46
Taiwan[8]	247	200	234	235	153	256
Thailand	18	17	15	66	88	87
Turkey[1]	149	161	189	474	312	499
Vietnam, Socialist Republic of	--	--	--	e147	134	225
Oceania: Australia[e]	217	218	198	194	196	182
Other:						
North and Central America[9]	--	--	--	32	27	30
South America[10]	--	--	--	34	32	28
Africa[11]	--	--	--	98	93	100
Asia[12]	--	--	--	39	26	44
Oceania[13]	--	--	--	46	34	23
World Total	r44,578	46,722	48,366	r42,677	42,527	47,732

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Calendar year referring to the first part of the split year.
[2]Fertilizer year: August to July.
[3]Fertilizer year: June to May.
[4]Including quantities used for forest fertilization.
[5]Fertilizer year: November to October.
[6]United States Bureau of Mines estimate based on United Nations estimate for People's Republic of China and Taiwan (reported as a single figure) less the British Sulphur Corp. Ltd. reported figure for Taiwan alone.
[7]Data for West Malaysia only.
[8]Source: The British Sulphur Corp. Ltd. Statistical Supplement No. 14, November-December 1976, p. 14.
[9]Includes Barbados, Belize, Guadeloupe, Haiti, Honduras, Martinique, St. Kitts-Nevis-Anguilla, St. Lucia, and St. Vincent.
[10]Includes Bolivia, Guyana, Paraguay, Surinam, and Uruguay.
[11]Includes Angola, Benin, Botswana, Burundi, Central African Empire, Chad, Congo, Equatorial Guinea, Ethiopia, Gambia, Ghana, Guinea, Liberia, Libya, Malagasy Republic, Malawi, Mali, Niger, Reunion, Rwanda, Sierra Leone, Somalia, Swaziland, Togo, Uganda, United Republic of Cameroon, Upper Volta, and Zaire.
[12]Includes Cyprus, Jordan, Khmer Republic, Laos, Mongolia, Nepal, and Singapore.
[13]Includes Fiji Islands, New Zealand, and Papua New Guinea.

Source: Statistical Office of the United Nations, Statistical Yearbook, 1976 (New York, 1977, pp. 288-289, 584-586) unless otherwise specified.

TECHNOLOGY

Higher energy costs and the rising demand for fertilizer have underscored the need for basic research into ways to increase nitrogen availability to agricultural plants. Research has focused on increasing the efficiency and amount of natural nitrogen fixation, introducing the process into plants in which it does not normally occur, and finding a low-energy industrial route that could replace the present energy-intensive process for making ammonia.[86]

A 5-year, $1.3 million United Nations research program to investigate natural nitrogen fixation will be implemented by the International Rice Research Institute in the Philippines, in collaboration with Cornell University and Boyce Thompson Institute in the United States. The new project will study rates of nitrogen fixation, the role of bacteria, and environmental factors.[87]

The Dow Chemical Co. brought onstream a facility to produce nitrapyrin, a nitrification inhibitor for use with anhydrous ammonia, urea, and ammoniacal-type fertilizers. The product stabilizes the fertilizers through its activity on specific bacteria that are responsible for rapid conversion of ammonium nitrogen in soil. The result is that more ammonium nitrogen is available for use by plant life and less is lost to nitrite and nitrate conversion and potential leaching from the soil.[88]

A high-priority project of the Tennessee Valley Authority (TVA) is reducing the fertilizer industry's dependence on natural gas as the hydrogen source for ammonia production. Accordingly, a prototype coal gasification plant under development is scheduled to be in operation in 2 to 3 years.[89]

TVA's new pipe-cross reactor process for the manufacture of ammonium phosphate eliminates the need for natural gas to dry the final product. Chemical heat produced by the reactants in the pipe-cross reactor is usually sufficient to completely dry the granular material. Elimination of drying equipment would also significantly reduce the cost of plants using the process.[90]

The Danish firm Haldor Topsoe introduced an improved design of its ammonia synthesis converter with a heat exchanger between the two radial flow catalyst beds. The new design provides ammonia conversion of 22% instead of 16%.[91]

A device that vaporizes fuel oil and thus will permit ammonia plant operators to use liquid fuels in furnaces fitted with natural gas burners has been developed by Allied Chemical Corp. The new system permits firing oil, gas, or any mixture of the two in existing burners, without making extensive modifications to piping.[92]

Production of ammonia from the exhaust gas of a stationary engine is possible with a new patented process developed by the Institute of Gas Technology. The major potential application is in converting irrigation pump exhaust gas into ammonia, which could be applied in the irrigation water. The process involves the reaction of carbon monoxide and water to form hydrogen, which reacts with nitric oxide to form ammonia.[93]

A new waste treatment plant due onstream in early 1978 at North Lake Tahoe, Calif., will incorporate an ammonia removal and recovery process to produce a 40% ammonium sulfate solution. Ammonium ions are absorbed in beds of the mineral clinoptilolite, which are regenerated by a concentrated sodium chloride solution. The ammonium sulfate solution will be suitable for application by farmers or for blending by fertilizer manufacturers. Sale of the fertilizer material should cut operating expenses of the plant by 60% compared with other tertiary treatment methods. However, the initial cost of the process amounts to 10% of the cost of the entire system.[94]

A report from the National Oceanic and Atmospheric Administration, based on a numerical model of the atmosphere, stated that nitrogen fertilizers are having little effect on the earth's ozone layer. The amount of fertilizer currently used adds only about 2 million tons of nitrous oxide to the estimated 1.4 billion tons already in the atmosphere. The study concluded that if nitrogen fertilizer use increased 6% annually until the year 2000 then leveled off, ozone would decrease somewhere between 1% and 10%.[95]

Skid-mounted stripping units that recover unreacted ammonia and urea can be added to existing urea plants to enable producers to meet EPA effluent standards. The stripping process recovers unreacted materials in the vapor phase at synthesis pressure and condenses them before they are returned to the reactor, thus cutting

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[86]Graff, G. M. Keeping the World's Breadbasket Full. Chem. Week, v. 118, No. 6, Feb. 11, 1976, pp. 28-38.
Skinner, K. J. Nitrogen Fixation. Chem. & Eng. News, v. 54, No. 41, Oct. 4, 1976, pp. 22-35.

[87]Chemical Week. UN Study Seeks Nitrogen Fixation Answers. V. 118, No. 18, May 5, 1976, p. 29.

[88]Chemical Marketing Reporter. Dow Starts Up Facility for Nitrogen Stabilizer. V. 210, No. 19, Nov. 8, 1976, p. 28.

[89]Chemical & Engineering News. TVA Fertilizer Developments Move Along. V. 54, No. 43, Oct. 18, 1976, pp. 34-36.

[90]Chemical Marketing Reporter. TVA Fertilizer Process Cuts Natural Gas Use. V. 209, No. 23, June 7, 1976, p. 12.

[91]Chemical & Engineering News. Concentrates. Technology. V. 54, No. 14, Apr. 5, 1976, p. 14.

[92]Chemical Week. Allied Method Enables Natural Gas Burners To Use Liquid Fuels. V. 119, No. 3, July 21, 1976, p. 36.

[93]———. Stationary-Engine Exhaust Is Source of Fertilizer. V. 118, No. 9, Mar. 3, 1976, p. 27.

[94]———. Converting Sewage Into Savings. V. 118, No. 2, Jan. 14, 1976, p. 47.

[95]Chemical & Engineering News. Concentrates. Science. V. 54, No. 18, Apr. 26, 1976, p. 16.

energy costs by up to 15% and increasing yields.[96]

Gulf Oil Chemicals Co. has developed a catalytic process designed to be retrofitted to existing nitric acid plants. Nitrogen oxides in the stack gas are selectively reduced using an aluminosilicate, molecular-sieve catalyst. In operation, ammonia is mixed with the tail gas and is adsorbed preferentially along with nitrogen oxide molecules. They react to form nitrogen and water, which are then desorbed.[97]

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[96]Chemical Week. Urea Makers Can Strip Away Waste Problems. V. 119, No. 14, Oct. 6, 1976, pp. 33-34.

[97]———. New Unit for Nitric Plants Knocks Out NOX. V. 119, No. 4, July 28, 1976, p. 33.

Peat

By Donald P. Mickelsen[1]

U.S. peat production was up sharply in 1976 to 969,459 tons, 26% over 1975 production. This was principally due to an increase in the number of operations producing over 25,000 short tons annually. The number of active operations, however, decreased by seven, with several existing and planned operations being prevented from producing since they were unable to obtain environmental permits. Production in 1976 increased in eight States, with the largest production gains occurring in Pennsylvania, Indiana, and Michigan.

Commercial sales of peat also rose sharply, increasing to 947,462 tons, 27% above sales in 1975. The average value per ton of peat sold, f.o.b. plant, increased from $16.49 in 1975, to $18.04 in 1976; raising the total value of peat sold by 39% to $17.1 million.

Imports increased about 16% in 1976 and provided about 26% of the peat available for consumption in the United States. Canada provided 97% of the peat imported.

Estimated world production remained at 223 million tons, about 95% of which was in the U.S.S.R.

Table 1.—Salient peat statistics

	1973	1974	1975	1976
United States:				
Number of operations	98	102	109	102
Production short tons	634,503	731,004	771,716	969,459
Commercial sales do	620,583	705,995	745,636	947,462
Value thousands	$7,547	$10,989	12,294	$17,096
Average per ton	$12.16	$15.56	$16.49	$18.04
Imports short tons	323,501	326,530	290,358	338,051
Available for consumption[1] do	944,084	1,032,525	1,035,994	1,285,513
World: Production thousand short tons	220,145	r220,509	r223,960	222,856

[1]Commercial sales plus imports.

DOMESTIC PRODUCTION

Peat is broadly classified in the United States as moss peat, reed-sedge peat, and humus, according to the type of plant matter from which it is formed and the degree of decomposition. Moss peat is a type that has been formed principally from sphagnum, hypnum, and/or other mosses; reed-sedge peat originated mainly from reeds, sedges, and other swamp plants; and humus peat is too decomposed for easy identification of its biological origin.

The 198,000-ton increase in 1976 production resulted from a larger output of humus peat in Pennsylvania and Indiana. Humus production was 92% greater than in 1975, owing to greatly increased output by several existing operations. Of the total peat production in 1976, 46% was reed-sedge peat, 32% was humus, and 22% was moss peat.

Peat was produced in 21 States in 1976. Michigan remained the largest producer, with 31% of the Nation's output. The next four largest producing States were Indiana, Pennsylvania, Illinois, and Florida.

Active operations in the United States decreased from 109 to 102, but the average output per plant increased greatly from

[1]Mineral specialist, Division of Coal.

7,080 tons in 1975 to 9,505 tons in 1976. Over three-fourths of the operations, however, had outputs below the average with only 32 plants producing more than 5,000 tons. The increase in average output, as well as the increase in the total U.S. peat production, can be attributed to the growth in the number and size of operations producing over 25,000 tons annually. These producers increased from five in 1975 to nine in 1976 and accounted for 63% of the total peat produced.

Production methods used in the United States varied with the size and conditions of the bog being worked. Almost all peat was harvested using conventional earthmoving and excavating machinery, or modified conventional machinery. Power shovels, bulldozers, and front-end loaders were used in drained bogs; draglines, clam shells, and dredges were used in submerged deposits.

Peat bogs are generally covered with water, tree trunks, limbs, and other debris and must be properly cleared and drained before harvesting. In most instances, the bog is drained by constructing a series of feeder ditches and collecting canals so that the prevailing water table can be lowered and controlled. Since the surface of a peat bog is unstable, roads are built across the bog to provide a firm surface for trucks to travel on. The use of special wide-track treads enables other machinery to operate upon the bog surface.

Various harvesting techniques are employed at domestic peat operations. Generally, the peat is harvested by first loosening the top layer of the bog to a depth of approximately one-half inch with a disk, spike, or spring harrow. The loosened peat is then scraped into piles alongside the roads with bulldozers and loaded into trucks with front-end loaders. Other production methods include the use of vacuum harvesters, snow-blowing machines, draglines, and dredges.

Peat is usually processed for sale by air drying, shredding, screening, and in a few instances, by artificial drying. Processing equipment consists of a variety of screens, shredders, grinders, hammer mills, and gas- and oil-fired dryers.

In 1976, 36% of the peat was sold as produced with no processing other than air drying. About 63% of the peat was shredded before sale, and only 1% was subjected to thermal drying.

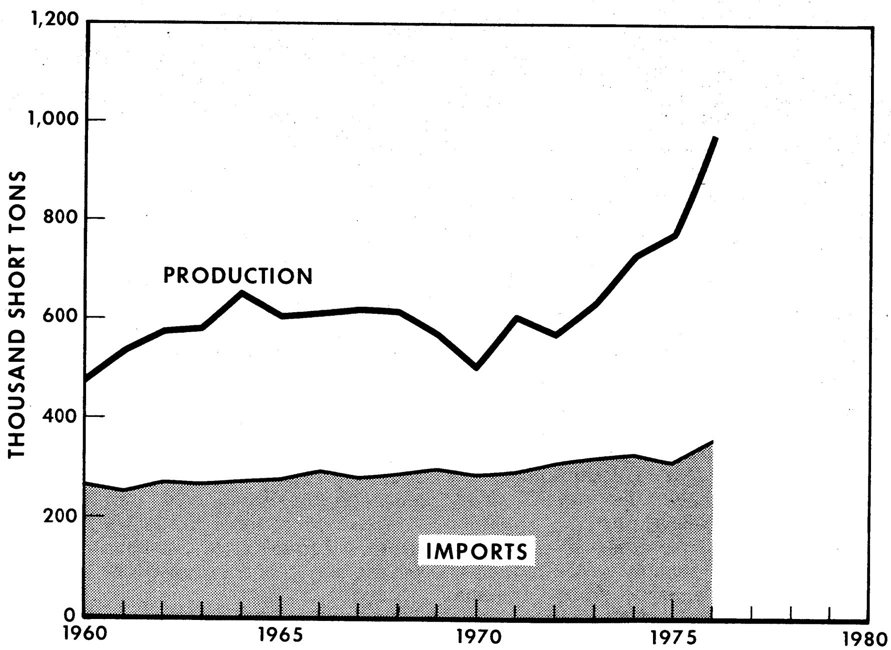

Figure 1.—Production and imports of peat in the United States.

Table 2.—Peat produced in the United States in 1976, by kind

(Short tons)

Kind	Unprepared	Processed: Shredded	Processed: Kiln-dried only	Processed: Shredded and kiln-dried	Total
Moss	69,362	144,479	--	1,500	215,341
Reed-sedge	165,436	277,794	--	1,500	444,730
Humus	118,004	188,343	687	2,354	309,388
Total	352,802	610,616	687	5,354	969,459

Table 3.—Production and commercial sales of peat in the United States in 1976, by State

State	Active plants	Production (short tons)	Commercial sales: Quantity (short tons)	Commercial sales: Value: Total (thousands)	Commercial sales: Value: Average per ton
Colorado	9	33,201	33,201	$238	$7.18
Florida	7	82,652	78,814	1,287	16.33
Illinois	4	84,662	87,087	763	8.76
Indiana	14	145,661	144,261	1,716	11.89
Maine	4	4,781	4,708	173	36.67
Maryland	1	2,891	2,304	W	W
Michigan	16	300,103	300,050	3,714	12.38
Minnesota	4	26,429	26,429	1,504	56.93
New Jersey	4	26,298	21,776	568	26.07
New York	5	34,075	32,181	684	21.25
Ohio	6	3,195	2,998	121	40.30
South Carolina	1	15,015	15,015	W	W
Washington	5	14,060	14,060	103	7.29
Wisconsin	4	9,742	10.598	W	W
Other States[1]	18	186,694	173,980	6,226	35.79
Total	102	969,459	947,462	17,096	18.04

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes California, Georgia, Iowa, Massachusetts, Montana, North Dakota, Pennsylvania, and values indicated by symbol W

Table 4.—Relative size of peat operations in the United States

Size	1975 Active plants: Number	1975 Active plants: Percent of total	1975 Production: Short tons	1975 Production: Percent of total	1976 Active plants: Number	1976 Active plants: Percent of total	1976 Production: Short tons	1976 Production: Percent of total
Under 500 tons	22	20.2	3,597	0.5	23	22.5	3,393	0.4
500 to 999 tons	11	10.0	7,629	1.0	15	14.7	11,460	1.2
1,000 to 4,999 tons	44	40.4	111,507	14.5	32	31.4	83,336	8.6
5,000 to 14,999 tons	18	16.5	153,558	19.9	16	15.7	135,614	14.0
15,000 to 24,999 tons	9	8.3	176,825	22.9	7	6.9	128,342	13.2
Over 25,000 tons	5	4.6	318,600	41.2	9	8.8	607,314	62.6
Total	109	100.0	771,716	100.0	102	100.0	969,459	100.0

CONSUMPTION AND USES

The amount of peat available for consumption in 1976 increased 24% over that in 1975. This was principally due to substantial increases in commercial sales of peat and peat imports.

Peat was used for a variety of purposes, but 86% of total commercial sales reported by producers were for general soil improvement. Among the principal markets for this peat were nurseries and greenhouses, which used peat as a mulch and as a medium for growing plants and shrubs; landscape gardeners and contractors, who used peat for building and maintaining lawns and golf-course greens and for transplanting trees and shrubs; and garden, hardware, and variety stores, which sold peat to homeowners for mulching and improving lawn and garden soils. The remaining 14% of the peat was sold principally for use in potting soils, a market that has grown greatly in the past few years along with the household plant industry. Other uses for peat were for packing flowers and shrubs for shipment, and for mushroom beds, earthworm culture, seed inoculant, and mixed fertilizers. About 69% of the peat sold commercially by producers was packaged, and this accounted for over 76% of the total value of sales. This was a 59% increase over packaged sales in 1975 and is a continuation of the industry trend in the past several years toward wider distribution and marketing, facilitated by the use of polyethylene bags.

Package sizes varied greatly, but most producers used 40-pound bags. Smaller bags have been used increasingly in the past several years for marketing both peat and potting soils. Five-, ten-, and twenty-pound bags of each have been commonly produced for household use. About 51% of the packaged peat sold in 1976 was of the reed-sedge type, 38% was humus, and 11% was moss peat.

States leading in sales of packaged peat in 1976 were Michigan, Pennsylvania, Indiana, and Illinois, in order of volume. Together, these States reported 84% of the total sales of packaged peat. Michigan, the largest producer, had 39% of the total sales.

Of the bulk peat sold in 1976, 62% was reportedly sold for general soil improvement. The remainder was sold mainly for use in potting soils, for packing flowers and shrubs, and in mixed fertilizers. States leading in sales of bulk peat were Florida, Indiana, and Michigan, in order of volume.

Table 5.—Commercial sales of peat in the United States in 1976, by kind and use

Use	Moss		Reed-sedge		Humus	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Bulk:						
Soil improvement	64,844	$694	80,481	$1,114	36,535	$390
Other uses	79,367	1,045	20,551	522	9,723	253
Total	144,211	1,739	101,032	1,636	46,258	643
Packaged:						
Soil improvement	51,454	2,009	329,921	3,959	252,078	6,623
Other uses	14,352	356	7,823	82	333	49
Total	65,806	2,365	337,744	4,041	252,411	6,672
Total						
Soil improvement	116,298	2,703	410,402	5,073	288,613	7,013
Other uses	93,719	1,401	28,374	604	10,056	302
Grand total	210,017	4,104	438,776	5,677	298,669	7,315

Table 6.—Commercial sales of peat in the United States in 1976, by use

Use	In bulk		In packages		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Soil improvement	181,860	$2,198	633,453	$12,591	815,313	$14,789
Seed inoculant	175	2	--	--	175	2
Packing flowers, shrubs,etc	25,679	356	4,548	64	30,227	420
Potting soils	47,260	898	12,325	265	59,585	1,163
Mushroom beds	2,831	61	--	--	2,831	61
Earthworm culture	4,919	59	9	(1)	4,928	59
Mixed fertilizers	20,232	188	--	--	20,232	188
Other	8,545	256	5,626	158	14,171	414
Total	291,501	4,018	655,961	13,078	947,462	17,096

[1]Less than 1/2 unit.

PRICES AND SPECIFICATIONS

Prices of peat at individual operations varied greatly in 1976, with the price depending mainly upon the kind of peat sold, the amount of processing, and whether the peat was sold in bulk or package form.

The overall average value per ton, f.o.b. plant, for all peat sold in 1976 was $18.04, up from $16.49 in 1975. Most of the increase was attributed to higher average receipts for peat sold in 14 States, with significant price increases occurring in Minnesota, Ohio, Massachusetts, Pennsylvania, and Iowa.

The average value of bulk peat increased 15% to $13.78 per ton. Packaged prices decreased 1% to $19.94, probably owing to competition in the marketplace. Increased sales at higher prices by producers in Florida, Michigan, and Indiana contributed to the higher average price of bulk peat. The unit value of packaged peat was influenced mainly by packaged sales in Pennsylvania, Michigan, Minnesota, and Indiana.

In a few instances, when producers did not report the value of peat sold, the sales value was estimated based on the average value of a similar type of peat sold within the State.

Imported peat had a total value of $29.5 million in 1976. This value was 24% greater than in 1975, the average value per ton increased from $82.17 to $87.24.

Although the average value per ton of imported peat was four times that of domestically produced packaged peat, these values were not comparable because imported peat was less dense and of higher quality than domestic peat. Each 100 pounds of a typical air-dried imported peat measured approximately 12 bushels, whereas the same weight of a typical domestic peat measured only 3 or 4 bushels. The imported product was usually sold on a volume rather than a weight basis. A few domestic operations, in the northern latitudes, produced peat with properties similar to those of the imported kind.

FOREIGN TRADE

The quantity of peat imported into the United States in 1976 totaled 338,000 short tons. This tonnage was 16% greater than that imported in 1975 and represented a recovery from the previous year's depressed import market. Canada provided 97% of the peat imports. Most of the remaining imports of peat were supplied by Europe. European shipments to the United States increased 20% in 1976, in contrast to a 48% decrease in 1975.

Imported peat was classified according to use, either as poultry and stable grade or as fertilizer grade. Except for a duty of $0.50 per long ton levied on poultry and stable grade peat from countries with centrally controlled economies, there was no tariff on peat.

Foreign peat entered the United States through 28 customs districts in 1976, but 89% of the total was shipped through the customs districts of Buffalo, N.Y., Detroit, Mich., Ogdensburg, N.Y., Pembina, N.Dak., Portland, Maine, St. Albans, Vt., and Seattle, Wash. The largest quantity, 94,000 tons, was shipped through the Ogdensburg district.

Table 7.—U.S. imports for consumption of peat moss, by grade and country

Country	Poultry- and stable-grade		Fertilizer-grade		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1975						
Canada	6,243	$455	276,947	$22,858	283,190	$23,313
Denmark	7	(1)	--	--	7	(1)
Germany, West	337	26	6,567	512	6,904	538
Guatemala	1	3	--	--	1	3
Ireland	10	(1)	--	--	10	(1)
Mexico	18	3	--	--	18	3
Netherlands	10	1	--	--	10	1
United Kingdom	--	--	218	1	218	1
Total	6,626	488	283,732	23,371	290,358	23,859

See footnotes at end of table.

Table 7.—U.S. imports for consumption of peat moss, by grade and country —Continued

Country	Poultry- and stable-grade		Fertilizer-grade		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1976						
Canada	5,012	507	324,334	28,305	329,346	28,812
Chile	56	5	38	4	94	9
China, Peoples Republic of	17	1	--	--	17	1
Finland	--	--	35	5	35	5
Germany, West	530	39	7,868	576	8,398	615
Ireland	--	--	22	1	22	1
Netherlands	3	1	--	--	3	1
Norway	--	--	13	36	13	36
Sweden	--	--	76	7	76	7
Switzerland	--	--	1	1	1	1
U.S.S.R	--	--	23	2	23	2
United Kingdom	--	--	23	2	23	2
Total	5,618	553	332,433	28,939	338,051	29,492

[1]Less than 1/2 unit.

Table 8.—U.S. imports for consumption of peat moss in 1976, by grade and customs district

Customs district	Poultry- and stable-grade		Fertilizer-grade		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Baltimore, Md	--	--	488	$42	488	$42
Boston, Mass	--	--	82	6	82	6
Buffalo, N.Y	107	$7	33,190	3,114	33,297	3,121
Charleston, N.C	--	--	57	5	57	5
Detroit, Mich	641	52	37,187	3,226	37,828	3,278
Duluth, Minn	--	--	12,174	1,299	12,174	1,299
Great Falls, Mont	--	--	17,377	1,331	17,377	1,331
Honolulu, Hawaii	17	1	--	--	17	1
Houston, Tex	50	3	280	20	330	23
Los Angeles, Calif	--	--	600	58	600	58
Miami, Fla	169	11	438	32	607	43
Milwaukee, Wis	--	--	17	1	17	1
Mobile, Ala	--	--	1,282	80	1,282	80
New Orleans, La	--	--	889	72	889	72
New York, N.Y	29	4	417	31	446	35
Nogales, Ariz	--	--	24	3	24	3
Norfolk, Va	3	1	584	36	587	37
Ogdensburg, N.Y	22	2	94,096	7,448	94,118	7,450
Pembina, N. Dak	762	101	27,018	2,888	27,780	2,989
Philadelphia, Pa	44	4	138	11	182	15
Portland, Maine	3,503	346	31,016	2,699	34,519	3,045
St. Albans, Vt	--	--	29,483	2,308	29,483	2,308
St. Louis, Mo	6	1	8	1	14	2
San Francisco, Calif	149	11	52	5	201	16
San Juan, P.R	--	--	1,271	96	1,271	96
Savannah, Ga	37	2	--	--	37	2
Seattle, Wash	61	6	42,848	4,030	42,909	4,036
Tampa, Fla	18	1	1,417	97	1,435	98
Total	5,618	553	332,433	28,939	338,051	29,492

Table 9.—Peat moss imported for consumption from Canada and West Germany in 1976, by grade and customs district

Customs district	Canada				West Germany			
	Poultry- and stable-grade		Fertilizer-grade		Poultry- and stable-grade		Fertilizer-grade	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Baltimore, Md	--	--	--	--	--	--	468	$35
Boston, Mass	--	--	--	--	--	--	82	6
Buffalo, N.Y	107	$7	33,177	$3,078	--	--	--	--
Charleston, N.C	--	--	--	--	--	--	57	5
Detroit, Mich	641	52	37,183	3,226	--	--	--	--
Duluth, Minn	--	--	12,174	1,299	--	--	--	--
Great Falls, Mont	--	--	17,377	1,331	--	--	--	--
Houston, Tex	--	--	--	--	50	$3	280	20
Los Angeles, Calif	--	--	--	--	--	--	600	58
Miami, Fla	--	--	--	--	169	11	438	32
Milwaukee, Wisc	--	--	17	1	--	--	--	--
Mobile, Ala	--	--	--	--	--	--	1,282	80
New Orleans, La	--	--	11	2	--	--	878	70
New York, N.Y	--	--	--	--	29	4	322	26
Nogales, Ariz	--	--	24	3	--	--	--	--
Norfolk, Va	--	--	--	--	--	--	584	36
Ogdensburg, N.Y	22	2	94,096	7,448	--	--	--	--
Pembina, N.Dak	762	101	27,018	2,888	--	--	--	--
Philadelphia, Pa	--	--	--	--	44	4	138	11
Portland, Maine	3,447	341	30,961	2,693	--	--	--	--
St. Albans, Vt	--	--	29,463	2,307	--	--	--	--
St. Louis, Mo	6	1	8	1	--	--	--	--
San Francisco, Calif	--	--	--	--	149	11	52	5
San Juan, P.R	--	--	--	--	--	--	1,271	96
Savannah, Ga	--	--	--	--	37	2	--	--
Seattle, Wash	27	3	42,825	4,028	34	3	--	--
Tampa, Fla	--	--	--	--	18	1	1,416	96
Total	5,012	507	324,334	28,305	530	39	7,868	576

WORLD REVIEW

World production of peat in 1976 was estimated at 223 million tons, practically the same as in 1975.

The U.S.S.R. was by far the largest peat producer, with an estimated 95% of world production. According to published U.S.S.R. figures, 145 million tons of peat was produced for agricultural use, and an estimated 66 million tons was used for fuel. Agricultural peat was used for general soil improvement and the manufacture of fertilizers, and fuel peat was used for generating electric power and for industrial and domestic heating.

Ireland ranked second in world peat production with an estimated 6.3 million tons, a 18% reduction from the 1975 output. Virtually all of Ireland's production was fuel peat used for generating electric power and for heating households. A small amount of agricultural peat was produced, principally for export.

West Germany was the third ranking country with 2.7 million tons, about the same output as in 1975. Most of this production was for agricultural use, with only 10% consumed as a fuel.

Other producers, in order of tonnage, were the United States, the Netherlands, Canada, and Finland. The combined output of these countries was about 1% of the world total. Although the United States was fourth in world production, it produced less than 0.5% of the world total.

Table 10.—Peat: World production, by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
Argentina	[r]11	10	[e]11
Australia	[r]2	3	[e]1
Canada, agricultural use	407	398	397
Denmark, fuel[2]	35	39	43
Finland:			
Agricultural use[e]	[r]101	[r]132	159
Fuel	128	220	238
France, agricultural use[e]	175	175	175
Germany, West:			
Agricultural use	2,062	2,419	2,398
Fuel	206	250	263
Hungary, agricultural use[e]	72	72	80
Ireland:			
Agricultural use	82	74	78
Fuel	4,693	7,579	6,225
Israel, agricultural use[e]	22	22	22
Japan[e]	80	80	72
Korea, Republic of, agricultural use[e]	4	4	4
Netherlands[e]	440	440	450
Norway:			
Agricultural use[e]	62	66	66
Fuel[e]	1	1	1
Poland:			
Agricultural use[e]	40	40	40
Fuel	5	5	5
Spain	29	38	[e]39
Sweden:			
Agricultural use	81	84	[e]85
Fuel	40	37	[e]35
U.S.S.R.:			
Agricultural use[e]	[r]145,000	[r]145,000	145,000
Fuel[e]	[r]66,000	[r]66,000	66,000
United States, agricultural use	731	772	969
Total	[r]220,509	223,960	222,856
Fuel peat included in total	71,108	74,131	72,810

[e]Estimate. [p]Preliminary. [r]Revised.
[1]In addition to the countries listed, Austria, Iceland and Italy produce negligible quanties of fuel peat, and East Germany is a major producer, but output is not officially reported and available information is inadequate for formulation of estimates of output levels.
[2]Sales.

TECHNOLOGY

Research conducted by the Department of Chemistry, University of Cincinnati, investigated the possible use of peat as a lightweight and inexpensive substitute for the XAD-2 polystyrene beads presently being used in shipboard filter cartridges.[2] These cartridges contain a filter agent which removes the oil from bilge water before it is discharged into waterways, in order to meet pollution laws. The filter materials coalesce the oil so that it can be separated by gravity. It was found that the coalescence capabilities of dried Irish peat and sulfuric-acid-treated Michigan peat when tested in distilled and synthetic seawater were comparable to that of the XAD-2 beads. Further research was required.

First Colony Farms, Inc., a large agricultural corporation, has been investigating peat as a source of fuel for electric-power generation.[3] Assisted by studies conducted by Ebasco, a private utilities consulting firm, First Colony estimated that the humus peat reserve on its land near Roper, N.C., could fuel a 1,600-megawatt powerplant for 35 years. First Colony purchased $300,000 worth of harvesting equipment from the U.S.S.R. to assist in harvesting the peat and planned to produce crops on the reclaimed land. There were, reportedly, environmental and political problems yet to be solved before the feasibility of the project could be evaluated.

The Institute of Gas Technology, Chicago, Ill., continued an Experimental Program for the Development of Peat Gasification for the Minnesota Gas Co. under contract with the U.S. Department of Energy.[4]. The first phase of the program consisted of deter-

[2]Smith, E.F. and H.B. Mark, Jr. The Use of Modified Forms of Peat as an Oil Coalescer. J. Environ. Sci. Health, v. A-11, Nov. 12, 1976, pp. 727-734.
[3]The News and Observer (Raleigh, N.C.). Peat Bogs May Yield New Fuel. July 19, 1977, p. 19.
[4]U.S. Energy Research and Development Agency. Experimental program for the Development of Peat Gasification. Fossil Energy Rept. FE-2469-8, Supp. Rept. 1, April 1977.

mining the chemical and physical characteristics of the different types of peat. It was found that reed-sedge peat had the most consistent content of nitrogen, oxygen, sulfur, and ash. The second phase investigated the gasification reactivity of peat using a series of thermobalance tests. It was found that although peat is two to four times as reactive as bituminous coal, the carbon-to-gas conversion efficiency was lower because of the low calorific value of peat and also because of production of liquid chemical byproducts. It was demonstrated that about 43% of the energy value in peat could be recovered in a high-Btu gas stream and that another 27% of this energy could be recovered in the chemical byproducts.

An economic evaluation was projected based on an extrapolated Hygas plant design using reed-sedge peat. It was estimated that investment in an 80-billion-Btu-per-day, peat-to-gas conversion plant would total $219 million. The production cost of the gas was estimated to be $2.14 per million Btu over a 20-year period, assuming a 90% steam factor and a delivered price of $5 per ton for peat. The major byproduct would be about 1 barrel of chemical byproducts, mostly benzene, naphthalene, and phenols, per 10,000 standard cubic feet of gas.

Perlite

By A. C. Meisinger[1]

Crude perlite production by the domestic industry in 1976 was the second highest on record for the quantity mined (727,000 tons) and for the quantity sold or used (553,000 tons) by crude ore producers for expanding. Value of crude perlite output was $9.4 million, or 29% greater than the previous record high set in 1975. New Mexico continued to be the major perlite-producing State with 86% of the total crude ore mined and established a record 481,368 tons sold or used from five mines, compared with the previous high of 480,024 tons in 1974.

Average value of crude perlite sold or used was $17 per ton or an increase of 19.5% over the previous record value in 1975.

Domestic perlite expanders set alltime highs in output of expanded perlite in 1976. The quantity produced was 438,000 tons compared with the previous high of 427,000 tons in 1972, and the quantity sold or used was 432,000 tons compared with the previous high of 421,000 tons in 1972. The value of expanded perlite sold or used was a new record of $41.0 million, compared with the old record of $34.3 million in 1975. Combined output of several new expanding plants contributed to the 1976 record total output. Illinois and Texas were the leading expanded perlite-producing States.

Table 1.—Crude and expanded perlite produced and sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Crude perlite						Expanded perlite		
	Quantity mined	Sold		Used at own plant to make expanded material		Total quantity sold and used	Quantity produced	Sold or used	
		Quantity	Value	Quantity	Value			Quantity	Value
1972	649	224	2,540	321	3,691	545	427	421	28,397
1973	759	238	2,771	306	2,819	544	424	418	28,005
1974	676	275	3,544	280	3,480	555	423	419	30,808
1975	706	239	3,407	273	3,874	512	401	394	34,258
1976	727	288	4,908	265	4,489	553	438	432	41,017

DOMESTIC PRODUCTION

The quantity of crude perlite produced by 11 companies at 12 mines in 6 States in 1976 was 727,000 tons, or 3% greater than that in 1975. New Mexico, with five mining operations, continued to be the principal source of crude perlite in the United States. New Mexico produced 86% of the mined ore in 1976, followed by Arizona, California, Colorado, Nevada, and Idaho in descending order of production. The quantity of crude perlite ore sold or used in New Mexico was a record high of 481,368 tons.

Crude perlite sold or used by producers totaled 553,000 tons valued at $9.4 million compared with 512,000 tons valued at $7.3

[1]Industry economist, Division of Nonmetallic Minerals.

million in 1975. The increase of 8% in quantity over that of 1975 was attributed in part to the opening in 1976 of the new mining and processing facilities of Grefco, Inc., at Socorro, N.Mex. The increase of 29% in value over that of 1975 established a new record in total sales value of crude perlite to expanding plants.

Producers of crude perlite during the year were Filters International, Inc., Harborlite Corp., and Guzman Construction Co. in Arizona; American Perlite Corp. in California; Persolite Products, Inc. in Colorado; Oneida Perlite Corp. in Idaho; Delamar-Mackie Perlite and United States Gypsum Co. in Nevada; and Grefco, Inc., Johns-Manville Sales Corp., Silbrico Corp., and United States Gypsum Co., all with operations in New Mexico.

The quantity of expanded perlite produced at 74 plants in 32 States totaled a record high of 438,000 tons, or 9% more than that produced at 69 plants in 29 States in 1975. The quantity (432,345 tons) and value ($41 million) of expanded perlite sold or used were alltime highs and represented increases of 10% in quantity and 20% in value compared with 1975 figures.

Leading States in descending order of expanded perlite production in 1976 were Illinois, Texas, Kentucky, Mississippi, Colorado, Pennsylvania, California, New Jersey, and Florida. California and Texas each had seven producing plants, followed by Illinois, Indiana, and Pennsylvania with five each. New expanding plants in operation in 1976 were located in California, Pennsylvania, Texas, Utah, Virginia, West Virginia, and Wyoming.

Table 2.—Expanded perlite produced and sold or used by producers in the United States

State	1975				1976			
	Quantity produced (short tons)	Sold or used			Quantity produced (short tons)	Sold or used		
		Quantity (short tons)	Value (thousands)	Average value per ton		Quantity (short tons)	Value (thousands)	Average Value per ton
California	25,009	24,300	$2,695	$110.91	28,050	27,359	$3,282	$119.97
Florida	21,286	21,344	1,431	67.06	23,784	23,611	1,552	65.73
Indiana	15,499	15,144	1,122	74.08	15,171	15,102	1,228	81.28
Kansas	800	831	123	147.96	991	932	140	150.00
Missouri	5,400	5,392	658	122.03	5,700	5,644	689	122.08
New York	5,371	5,229	664	126.98	6,776	6,715	878	130.68
Ohio	11,997	11,941	996	83.39	11,714	11,703	952	81.34
Pennsylvania	33,693	33,343	2,619	78.55	33,085	33,122	2,707	81.74
Texas	39,777	38,577	2,580	66.87	38,073	37,830	3,857	101.97
Other States[1]	242,442	237,870	21,370	89.84	274,745	270,327	25,732	95.19
Total	401,274	393,971	34,258	86.96	438,089	432,345	41,017	94.87

[1]Includes Colorado, Georgia, Idaho, Illinois, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Mississippi, Nebraska (1975), Nevada, New Hampshire, New Jersey, North Carolina (1976), Oregon, Tennessee, Utah, Virginia (1976), West Virginia (1976), Wisconsin, and Wyoming (1976).

CONSUMPTION AND USES

Domestic consumption of expanded perlite increased 10% in quantity over that of 1975 and was an alltime high of 432,345 tons. A percent distribution by end use is shown in table 3. In descending order of quantity sold or used, the principal uses for expanded perlite in 1976 were roof insulation board, filter aids, acoustical tile, horticultural aggregate, concrete aggregate, and plaster aggregate. Expanded perlite sold or used for filter aids, acoustical tile, and insulation board combined, accounted for 291,000 tons or 67% of the total quantity and 57% of the total value of sales in 1976.

Compared with 1975, plaster aggregate use declined from 8% to 6%; concrete aggregate, from 8% to 7%; and formed products,

Table 3.—End use of expanded perlite

(Percent)

Use	1975	1976
Filter aid	21	21
Plaster aggregate	8	6
Concrete aggregate	8	7
Horticultural aggregate	8	9
Low-temperature insulation	1	2
Masonry and cavity fill insulation	3	3
Fillers	1	1
Formed products	11	10
Other[1]	39	41

[1]Includes insulation board.

from 11% to 10% of total consumption. End-use categories that remained unchanged in 1976 were filter aid (21%), masonry and cavity fill insulation (3%), and fillers (1%). Expanded perlite used as horticultural aggregates continued to increase in popularity (from 5% in 1973 to 9% in 1976) and accounted for nearly 36,900 tons in 1976 compared with 31,200 tons in 1975. Low-temperature insulation and various other uses increased modestly in 1976. The "Other" uses category included (other than insulation board and acoustical tile) such items as pipe insulation, foundry applications, paint texturizers, oil absorbent, fines, and specialty products.

PRICES

Processed (crushed, cleaned, and sized) crude perlite was sold by producers to expanders at an average price of $17.04 per ton, or an increase of $2.78 per ton over that in 1975. Crude perlite used by producers in their own expanding plants was valued at $16.94 per ton, or an increase of $2.75 per ton compared with that in 1975. The weighted average price of crude processed perlite was $16.99 per ton, or an increase of $2.77 per ton over that of 1975.

Expanded perlite sold or used, according to expanders, was valued at $94.87 per ton compared with $86.96 per ton in 1975. Average values for expanded perlite by States ranged from $40 to $167 per ton, compared with the 1975 range of $36 to $186 per ton. Average prices per end use in 1976 ranged from $37 per ton for acoustical tile to $240 per ton for low-temperature insulation.

WORLD REVIEW

Greece.—Preliminary figures for crude and processed perlite (for export) in 1976 indicated a significant increase over 1975 production. Production of perlite in Greece for the 1974-76 period is given in the following table, in short tons:

	1974	1975	1976[p]
Crude ore	[r]234,800	177,500	259,800
Processed ore (for export)	125,900	124,700	131,400

[p]Preliminary. [r]Revised.

General Enterprises Sarides, S.A. (formerly L. K. Sarides Mining Enterprises) of Piraeous, commenced construction of a new perlite processing plant on Milos. Crude ore from the company's open pit mine will be processed in the plant and classified into three grades ranging from 0.5 millimeter to 2.5 millimeters in size. The company has also started improvements in the docking facilities at the port of Adamas for handling larger shipments of perlite for export.

Mexico.— Production of crude perlite from Mexican operations in 1976 totaled 16,000 tons, or 5,000 tons under the 1975 output.

Philippines.—Crude perlite produced in 1976 increased substantially, from 733 tons in 1975 to 1,818 tons.

Grefco, Inc., Los Angeles, Calif., in association with local Philippine interests, started construction of a filter aid plant near Legaspi, Albay, on the Island of Luzon. The expanding plant, scheduled to be in operation by mid-1977, will help to supply perlite filter aid demand in the Philippines and certain market areas of the Far East.

South Africa, Republic of.—The perlite mining operation of Pratley Perlite Mining Co. (Pty.) Ltd. went on stream at yearend. The deposit is on the Nxwala Estate, Zululand. The crude ore will be transported to a processing plant at Krugersdorp.

A joint venture between Grefco, Inc., Los Angeles, and Chemical Holdings, Ltd. of Sandton, Transvaal, to construct a filter aid plant at Olifantsfontein near Johannesburg, was announced by Grefco.

Crude Petroleum and Petroleum Products

By William B. Harper,[1] Bernadette C. Michalski,[2] John R. Reiss,[3] and Michelle R. Parker [4]

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Reflecting a moderate recovery in the economy coupled with an unusually severe winter, domestic demand[5] for petroleum products in 1976 increased sharply over 1975 and exceeded the previous high of 1973 by a slight margin. Sharp gains occurred in the demand for residual fuel oil and distillate fuel oil and moderate gains occurred in motor gasoline demand, as a result, overall domestic demand rose 6.9% to 17.5 million barrels per day (bpd) from 16.3 million bpd in 1975. Production of crude oil, lease condensate, and natural gas liquids continued to decline making it necessary to increase imports of crude oil and refined products significantly to have an adequate supply to meet demand.

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[5]Certain terms as used in this chapter are more or less unique to the petroleum industry. Principal terms and their meanings are: *Total demand.*—A derived figure representing total new supply plus decreases or minus increases in reported stocks (because there are substantial consumers' stocks that are not reported to the Bureau of Mines, this figure varies considerably from consumption as reported by the Federal Highway Administration of the Department of Transportation); *Domestic demand.*—Total demand less exports; *New supply of all oils.*—The sum of crude oil production plus production of natural gas liquids, plus benzol (coke oven) used for motor fuel, hydrogen, and other hydrocarbons plus imports of crude oil and other petroleum products; *Transfers.*—Crude oil conveyed to fuel-oil stocks without processing, or reclassification of products from one product category to another; *All oils.*—Crude petroleum, natural gas liquids, and their derivatives; *Exports.*—Includes shipments to U.S. territories, possessions, and free trade zones; *Imports.*—Includes receipts from U.S. territories, possessions, and free trade zones.

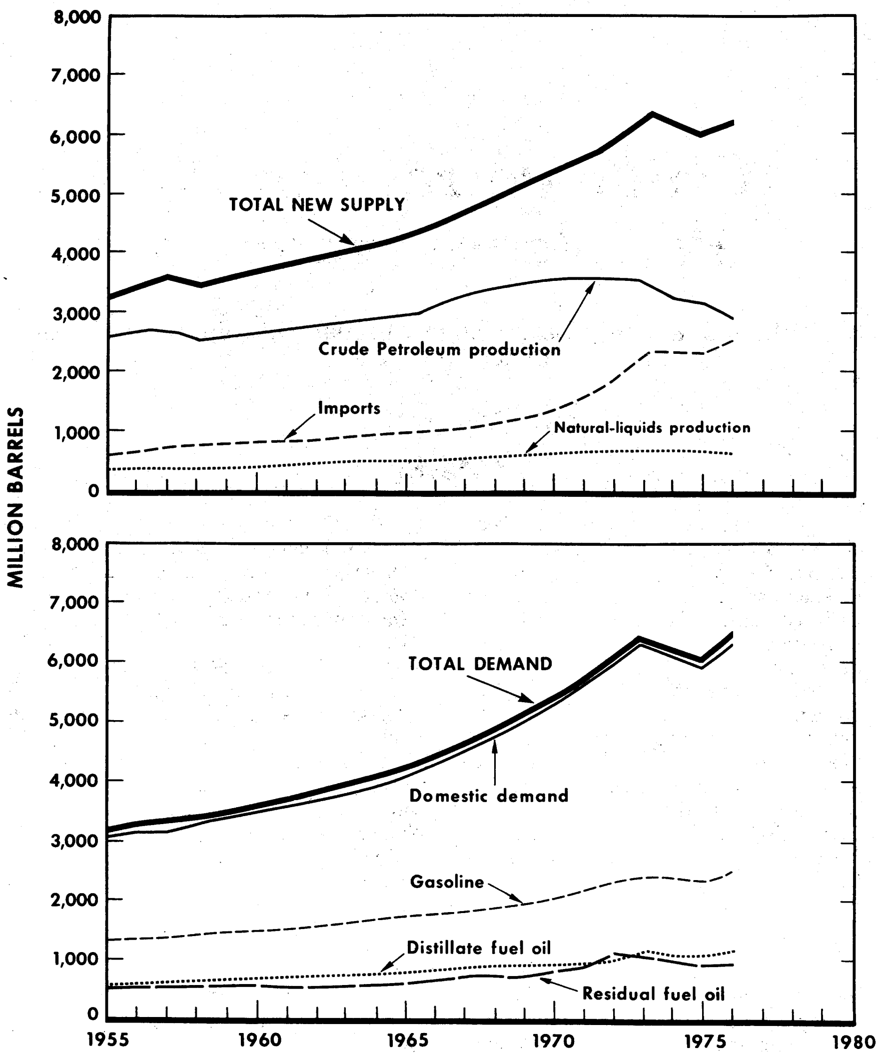

Figure 1.—Supply and demand of all oils in the United States.

New supply consists of domestic production of crude oil, lease condensate, natural gas plant liquids, and imports of crude oil and petroleum products. In 1976, imports supplied 42% of requirements compared with 37% in 1975. Imports of crude oil averaged nearly 5.3 million bpd in 1976, a 28.8% increase over the 4.1 million bpd average in 1975. Imports of products, such as increased receipts of residual fuel oil, more than offset declines in the imports of motor gasoline, jet fuels, and distillate fuel oil with a net result of an overall increase of 3% in 1976.

Refineries processed 4.9 billion barrels of oil in 1976, which is about 1 million bpd greater than in 1975. Foreign crude oil accounted for 39% of refinery input (table 18) compared with 33% in 1975. About 23% of the imported crude oil originated in Saudi Arabia in 1976 compared with 17% in 1975.

Construction of the 800-mile-long Trans-Alaska Pipeline was nearing completion. Oil was scheduled to start moving southward in late June 1977, filling the pipeline at about 300,000 bpd. Regular tanker loadings were expected to begin about mid-August 1977.

Table 1.—Salient statistics of crude petroleum, refined products, and natural gas liquids in the United States

(Thousand 42-gallon barrels unless otherwise indicated)

	1972	1973	1974	1975	1976[p]
Crude petroleum:					
Domestic production (including lease condensate)	3,455,368	3,360,903	3,202,585	3,056,779	2,976,180
World production	18,600,745	20,367,981	20,537,727	19,497,604	21,187,147
U.S. proportion percent	19	17	16	16	14
Exports[1]	187	697	1,074	2,146	2,941
Imports[2]	811,135	1,183,996	1,269,155	1,498,181	1,935,142
Stocks, end of year	246,395	242,478	265,020	271,354	285,471
Runs to stills	4,280,863	4,537,254	4,428,726	4,541,426	4,910,240
Value of domestic product at wells:					
Total thousands	$11,706,510	$13,057,905	$21,580,549	$23,116,059	$24,229,540
Average per barrel	$3.39	$3.89	$6.74	$7.56	$8.14
Total producing oil wells Dec. 31	508,443	497,378	497,631	500,333	499,236
Total oil wells completed during year (successful wells)	11,306	9,902	12,784	16,408	17,059
Refined products:					
Exports[1]	81,202	83,716	79,417	74,282	78,658
Imports (including unfinished oils and plant condensate)[3]	924,179	1,099,497	961,792	712,154	734,787
Stocks, end of year[4]	712,584	765,829	808,626	861,601	826,339
Completed refineries, end of year	277	284	290	287	291
Daily crude-oil capacity	13,775	14,489	15,169	15,428	16,610
Natural gas liquids:					
Production	638,216	634,423	616,098	595,958	587,045
Stocks, end of year	79,238	94,106	108,377	118,214	112,256
All oils:					
Total disposition of primary supply	6,076,346	6,406,613	6,163,519	6,038,842	6,471,002
Exports	81,389	84,413	80,491	76,428	81,599
Total domestic demand for products (including crude-oil losses)	5,994,957	6,322,200	6,083,028	5,962,414	6,389,403

[p] Preliminary (except for crude production and value).
[1]U.S. Department of Commerce data.
[2]Reported to the Bureau of Mines.
[3]U.S. Department of Commerce, Oil Import Administration and Federal Energy Administration data, except for unfinished oils and plant condensate which are Bureau of Mines data.
[4]Stocks of refined products also include stocks of unfinished oils, natural gasoline, plant condensate and isopentane.

The Federal Government offered 536 tracts of land for lease on the Outer Continental Shelf (OCS), during 1976. Much of it (475 tracts) was in unexplored areas off Alaska, the Atlantic States, and the Gulf of Mexico. One of the OCS sales was a drainage sale (the sale of unleased tracts of land that offset producing tracts) in the Gulf of Mexico. The bids received and the parties bidding on the drainage sale tracts, reflect the continued interest in the Gulf of Mexico as a mature oil and gas producing province, as shown in the following tabulation:

Offshore location	Date	Offered		Leased		Total high-bid accepted million dollars
		Tracts	Acreage	Tracts	Acreage	
Gulf of Mexico	Feb. 18	132	688,063	34	161,286	$175
Gulf of Alaska	Apr. 13	189	1,008,500	81	432,214	572
Atlantic coast	Aug. 17	154	876,722	101	574,993	1,135
Gulf of Mexico	Nov. 16	61	347,274	48	273,364	318
Total		536	2,920,558	264	1,441,757	$2,200

Subsequently, the OCS sale of August 17, 1976 located off the Atlantic coast was declared void by a Federal Judge of the U. S. District Court. The Secretary of the Department of the Interior asked the Justice Department to appeal the decision on rescinding the sale of drilling rights off the Atlantic coast. On April 25, 1977, the appeal was heard by the U.S. Court of Appeals. The Appelate Court reversed the decision, ruling that the Department of the Interior environmental studies fully met all legal requirements.

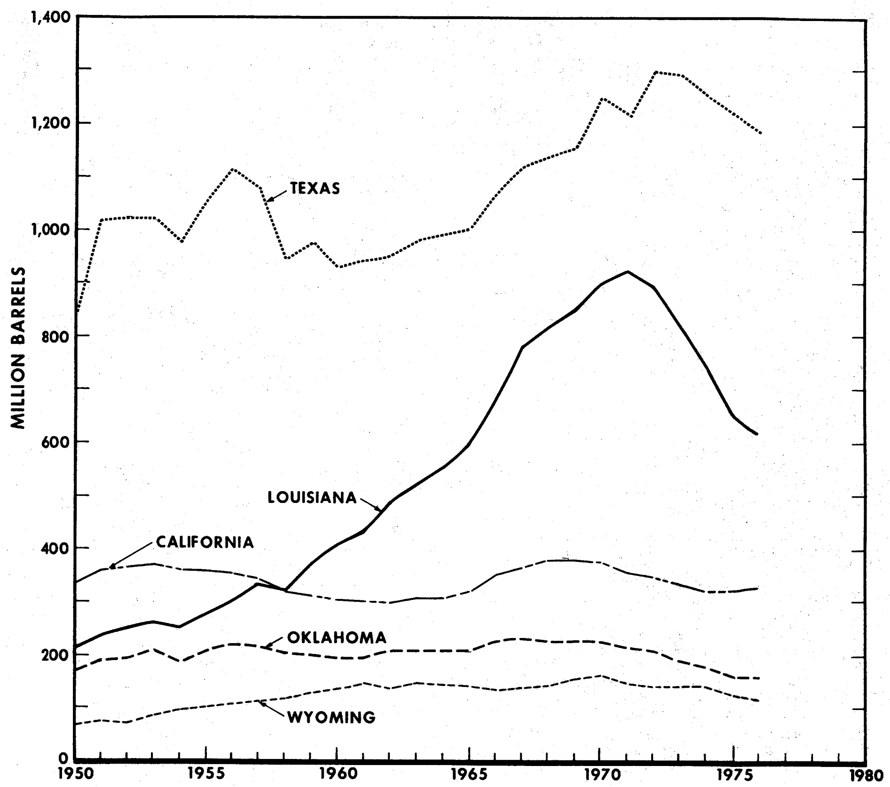

Figure 2.—Production of crude petroleum in the United States, by principal producing States.

CRUDE PETROLEUM

PRODUCTION

In 1976, production of crude oil, including lease condensate, continued the 6-year downtrend that began in 1970, but at a more moderate rate. In 1976, production totaled 2,976.2 million barrels which was 80.6 million barrels or 2.6% below that of 1975. In 1975, however, production was 145.8 million barrels or 4.6% below the 1974 level (table 1).

The largest declines in 1976 occurred in Louisiana, (44.3 million barrels) and Texas, (32.4 million barrels). These two States accounted for 95.2% of the decline, and there were declines of varying degrees in 17 other oil-producing States. Likewise, production increased in 13 oil-producing States, of which the most significant were, in millions of barrels, Michigan, 6.0, California, 3.8, Florida, 2.6, Arkansas, 2.0, North Dakota, 1.3, and Alabama, 1.3. A net increase of 3.8 million barrels in California reflected the opening of Elk Hills Naval Petroleum Reserve (NPR) No. 1 for exploration and development. Production in the East Central area of California, where NPR No. 1 is located, increased 18.4 million barrels in 1976 and more than offset the 14.6 million barrel decrease in other parts of the State. Other changes are shown in table 6.

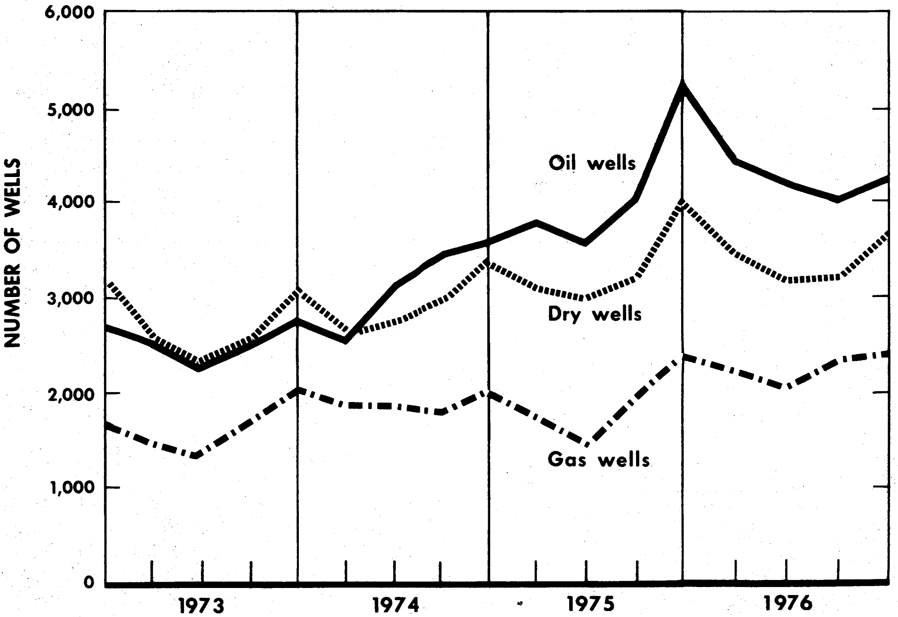

Figure 3.—Wells drilled for oil and natural gas in the United States, by quarter.

DRILLING ACTIVITY

There were 17,059 oil wells and 9,085 gas wells completed during 1976 in the United States, and 13,621 dry holes were drilled (excluding service and stratigraphic well core tests). This compared favorably with activities in 1975 when 16,408 oil wells and 7,580 gas wells were completed and 13,247 dry holes were drilled (table 8).

Total wells drilled relating to oil and gas exploration and production in 1976 were 41,455 totaling 185,344,695 feet. This was 2,358 more wells than the 39,097 wells and 178,505,507 footage drilled in 1975. The Hughes Tool Co. rig count reported a decline in the number of active rigs in operation; 1,808 during 1976 compared with 1,828 in 1975.

In early 1976 the decline in drilling rig activity was greater than the usual seasonal decline. The Federal Government removed crude oil produced from stripper well leases from price controls. A new classification of new oil as the amount of oil produced from the lease less the property's base production control level of oil produced in 1975, encouraged infill drilling. This resulted in the second half of 1976 rig activity rising to an average of 1,916 drilling rigs in operation, compared with the 1,707 average operating in the first half of the year. Infill drilling is development well drilling to expand the rate of production from the reservoir by increasing the number of producing wells. The lease holder must sell that amount of base production control oil at the lower tier price. Any production above the control level may be sold at the upper tier price.

A review of significant petroleum producing States showed that most States had increases in the number of rigs working. Texas, the most active State, averaged 654 rigs working during the year, up by nine units from 1975. Louisiana had an average of 242 rigs working during 1976, an increase of two units.

Other major States with higher activity included California, Mississippi, and Oklahoma. The major States that showed declines in activity were Colorado, Kansas, Michigan, New Mexico, Utah, and Wyoming.

Deep drilling is an indication of interest in a region to confirm hydrocarbon deposits, and stratigraphic test wells are drilled to obtain core samples and to accurately measure the subsurface for the petroleum potential. During 1976 deep drilling regional records were set; in the Texas Panhandle a well was drilled to 24,482 feet, Louisiana interests drilled a dry hole to 24,220 feet, and in Wyoming a well was drilled to 22,431 feet. The first well drilled offshore Massachusetts, the "Cost G-2" was drilled to 16,070 feet as a stratigraphic test. This well indicated the possibility of hydrocarbon generation from source beds that are present and abundant. Reservoir rocks throughout most of the geologic section have low permeability and porosity that range from 30% at the shallower depths to 10% at the deeper depths.

RESERVES

Based on the report of the Committee on Reserves of the American Petroleum Institute (API) proved reserves of crude oil as of December 31, 1976, were estimated at 30.9 billion barrels. Included in the reserve estimates are quantities of all liquids defined as crude oil, which geological and engineering data demonstrate with reasonable certainty to be recoverable under existing economic and operating conditions. Reserves at yearend 1976 were 1.7 billion barrels less than at yearend 1975, and continued the downtrend that began in 1971. Annual estimates by the API showed additions to reserves from new field discoveries, new reservoir discoveries, and extensions of old fields totaled 1.1 billion barrels. Domestic production of 2.8 billion barrels accounted for the 1.7-billion-barrel reduction in proved reserves (table 12).

The net change in proved reserves was positive for Indiana, Michigan, Nebraska, Ohio, Pennsylvania, and Tennessee, accounting for 1% of the proved reserves of 55 million barrels being added. The major producing States, Alaska, Texas, California, Louisiana, and Oklahoma, account for 88% of the United States proved reserves; these five States had a net reduction in proved reserves of 1.6 billion barrels. With this continued decline in proved reserves for the past 7 years, America has become dependent on foreign crude oil and petroleum products to meet the U.S. demand for petroleum and hydrocarbon products. In 1976, about 41% of domestic requirements was supplied from net imports of crude oil and petroleum products from foreign countries.

CRUDE SUPPLY

Total receipts of crude oil at refineries in 1976 were 4,920 million barrels, or 13.4 million bpd, an increase of 1.4 million bpd. Foreign receipts from overseas sources totaled 1.9 billion barrels, or nearly 5.3 million bpd, of which 72% originated from the Middle East and Africa. The Canadian Government continued to phase out its oil exports to the United States, while Mexico supplied the United States with 86,000 bpd in 1976, or 15,000 bpd more than in 1975.

CRUDE OIL CONSUMPTION

Oil refineries processed 4.9 billion barrels (13.4 million bpd), of which 61% was domestic crude oil and lease condensate and 39% originated in foreign countries. Based on operable refinery capacity at yearend 1976, refineries operated at 81% of distillation capacity of 16.4 million barrels per calendar day.

REFINING

Operable refinery capacity in the United States at yearend 1976 amounted to 16.4 million bpd, up 10% from yearend 1975. Refinery output averaged 13.4 million bpd during 1976, with motor gasoline accounting for nearly one-half of the production. Output of refined products from U.S. refineries accounted for only 80% of total demand for refined petroleum products in 1976, with the remainder supplied by imported products. About 50% of the residual fuel oil demand was met from domestic refinery output.

At yearend 1976, 291 petroleum refineries were dispersed across the country, with half of the operating capacity located in three States; California, Louisiana, and Texas. Expansion projects were planned or underway at numerous plants, and the largest refinery to be built in the United States in one phase was under construction at Caryville, La. The first units of that facility were started up during the fourth quarter of 1976, and the remaining construction projects at the 200,000-bpd refinery were scheduled to be completed early in 1977.

The Standard Oil Co. of California, Shell Oil Co., Standard Oil Co. (Indiana), Exxon Corp., and Texaco are the predominant refiners in the United States. Exxon's 510,000-bpd plant at Baton Rouge, La., was the largest in the country, and a 250,000-bpd expansion to Exxon's Baytown, Tex., plant under construction during 1976 and scheduled for completion in 1977, will expand that refinery to 640,000 bpd exceeded only by the Abadan refinery in Iran.

SUPPLY AND DEMAND

Demand for petroleum products in 1976 averaged 17.5 million bpd, a 6.9% increase over the 16.3 million bpd of 1975. The supply needed to meet this demand was derived in 1976 from production of crude oil and lease condensate averaging 8.1 million bpd plus production of natural gas liquids of 1.6 million bpd. This supply was supplemented with crude oil imports of 5.3 million bpd compared with 4.1 million bpd in 1975. Product imports in 1976 averaged 1.9 million bpd, which was about 67,000 bpd higher than 1975. A processing gain of 477,000 bpd filled the supply gap in 1976.

MOTOR GASOLINE

As a result of a moderate recovery in the economy, demand for motor gasoline in 1976 aggregated about 2.6 billion barrels or 7 million bpd, a 4% increase over 1975 (table 23). The Federal Highway Administration (FHA) of the Department of Transportation compiles data on motor gasoline use based on motor fuel tax reports filed with the States. Also, the FHA calculates data for highway and nonhighway use. The estimate of total usage 1976 averaged 7,133,000 bpd, or 4.9% above that of 1975.

Restrictions on motor gasoline by the Federal Energy Administration (FEA) under the Energy Policy and Conservation Act (EPCA) remained in full force and effect in 1976 and carried over into 1977.

Except for one premium gasoline marketed primarily on the east coast and in the south, all motor gasolines contained lead alkyl antiknock compounds until 1970 to increase octane quality. But with the agitation against the use of lead growing in intensity in 1971, automobile manufacturers in the United States began to build engines designed to operate on gasolines of nominal 91 Research Octane Number (RON). Unleaded and lowlead gasolines were introduced to supplement the conventional and well established gasolines such as premium and regular grades.

Since many motor vehicles in the United States, beginning with the 1975 model year, were equipped with catalytic converters, the Environmental Protection Agency (EPA) required most service stations, beginning in July 1974, to offer for sale at least one grade of 91 RON unleaded gasoline.

During 1976, tetraethyl lead was being phased out as the dominant motor gasoline octane booster, because the EPA considers the emissions from engines burning leaded fuels a health hazard. As a substitute for tetraethyl lead as an octane booster, domestic refiners used methylcyclopentadienyl manganese tricarbonly (MMT), produced by the Ethyl Corp., to produce large quantities of unleaded motor gasoline. Meanwhile, the EPA and domestic automobile manufacturers are pursuing investigations into the performance of MMT.

More than three-fourths of the motor gasoline sold in the United States during 1976 contained tetraethyl lead additives, but sales of unleaded fuels continued an upward trend. According to Ethyl Corp., sales of unleaded motor gasoline accounted for 17% of the total motor gasoline sales in January 1976, rose to 20% in June, and further increased to 23% in December.

During the year, the EPA issued regulations amending the schedule for phasing down the lead content in motor gasolines that requires refiners to meet average lead levels of 0.8 gram per gallon on January 1, 1978, and 0.5 gram per gallon on October 1, 1979. The Government revised the schedule in an effort to avoid possible shortages in gasoline supplies in 1977-78, while refiners installed the processing units necessary to produce unleaded fuel.[6]

AVIATION FUELS

Demand for aviation gasoline in 1976 totaled nearly 13.4 million barrels or about 5% less than in 1975 (table 25). From a peak of 38.1 million barrels in 1958, demand for aviation gasoline had shrunk to 13.3 million barrels by yearend 1976. Most of this reduction reflects the transition from the use of piston driven engines to the jet turbine types.

Aviation Gasoline.—Aviation gasoline, one of the most complex fuels produced, is subject to process control under ASTM-Specification D-910. In addition, there are other aviation gasoline specifications such as the U.S. Department of Defense (military specifications) and the British Ministry of Defense (D Eng RD specifications).

Jet Fuels.—The specification for aviation turbine fuels, ASTM D-1655, outlines requirements for three types of fuel: Jet A, a 40°C freeze point kerosine used within the

[6]Oil and Gas Journal. V. 74, No. 40, Oct. 4, 1976, p. 62.

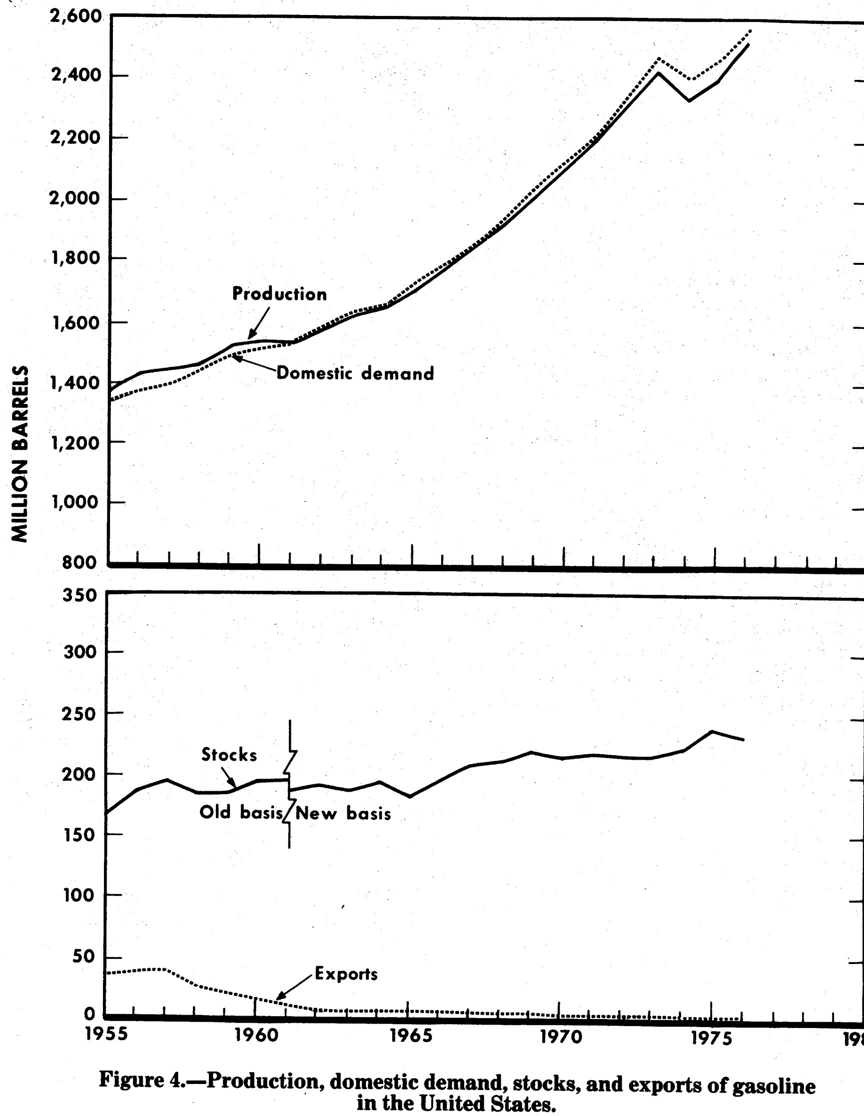

Figure 4.—Production, domestic demand, stocks, and exports of gasoline in the United States.

United States; Jet A-1, a 50° C freeze point kerosine which is the standard grade used for international flights; and Jet B, a widecut gasoline grade which at the present time is only in limited civil use.

Demand for kerosine-type jet fuel in 1976 averaged 789,000 bpd, which was slightly below the 1975 levels. Demand reached a peak of 842,000 bpd in 1973, and the subsequent reduction in fuel use reflects the impact of economies of operation adopted by the airlines. According to the Energy and Fuels Committee of the Air Transport Association (ATA), airlines have reduced the average number of flights by about 900 per day compared with 1973. At the same time, ATA estimated U.S. scheduled airlines in 1976 carried 223 million passengers, a 10.4% increase over the 1973 level. Over the same interval, kerosine-type jet fuel demand was 6.3% below that of 1973, as estimated by the Bureau of Mines.

Still another significant development was the expansion in production by refineries in the United States that resulted in a marked reduction in imports. From a peak of 176,000 bpd in 1973, imports have been in a downtrend. By 1976, imports shrunk to 61,000 bpd or 65.3% below the 176,000 bpd imported in 1973.

Naphtha-type jet fuel is used primarily by the military. In 1976, demand totaled 72.7 million barrels or 5% less than 1975.

Although FEA removed the allocation and price controls on naphtha-type jet fuels, controls on kerosine-type jet fuels and aviation gasoline remained in effect in 1976 and carried over into 1977.

LIQUEFIED GASES, ETHANE, AND ETHYLENE

Liquefied gases are derived from two sources; those produced at refineries are called liquefied refinery gases to distinguish them from liquefied petroleum gases obtained by processing natural gas. The liquefied petroleum gases (LPG) are all paraffins (propane, butane, and isobutane) and the standard specification is ASTM D-1835. The liquefied refinery gases (LRG) also contain paraffins but may also contain unsaturated hydrocarbons; such as the olefins (propylene, butylene, ethylene, etc.). The paraffins may be used as fuel (including as a blend with motor gasoline) or as feedstocks at petrochemical plants; the olefins are used primarily as petrochemical feedstocks.

Demand for ethane (including ethylene) rose 6.3% to 362,600 bpd in 1976 from 341,200 bpd in 1975. Ethane is used primarily to make ethylene, a building block for petrochemicals.

Domestic demand for LPG and LRG in 1976, excluding that blended into other products at refineries or terminals, increased 5.1% and exceeded 1 million bpd compared with 991,500 bpd in 1975. Propane accounted for 79.7% of liquefied gas demand in 1976, but if refinery propane and propylene is deducted from demand, the percentage shrinks to 577,800 bpd or 55.5%.

Propane was in strong demand during the heating season because of the impact of severe winter weather and a moderate recovery in the economy. As a result, with production down and demand up, stocks of plant propane totaled 69.7 million barrels at yearend, which was 8.4% below 1975. In 1976, the decrease in the production of propane and other natural gas liquids reflected the decline in natural gas production.[7]

Demand for plant propane rose 5.7% in 1976 to 830,200 bpd. Production at gas-processing plants in 1976 declined 5.5% and by yearend 1976 there was an 8.4% reduction in stocks to 69.7 million barrels from 76.1 million barrels at the end of 1975.

KEROSINE

The unusually severe weather east of the Mississippi River, particularly, helped lift demand for kerosine in 1976 to 61.9 million barrels, an increase of 169,200 bpd or 6.1%. Most of the increase in supply needs was met by imports and drawdowns on inventories. There was no noticable increase in refinery production of kerosine, but imports tripled and stocks at yearend 1976 were down 19.6% to 12.5 million barrels from the 15.6 million barrels of a year earlier (table 30). Nearly 80% of the domestic demand for kerosine (including range oil) is for space heating.

DISTILLATE FUEL OIL

Specifications for fuel oil are established by the ASTM Committee D-2 on Petroleum Products and Lubricants. The specification designation is ASTM D-396.

An extremely severe winter coupled with a mild recovery in general business resulted in a 9.8% increase in distillate demand in 1976, to 3.13 million bpd from 2.85 million bpd in 1975. Demand for distillate for heating rose about 3% to 1.38 million bpd from 1.34 million bpd in 1975. Severe and prolonged cold weather in the Midwest and on the eastern seaboard as far south as Florida boosted distillate demand sharply as reflected in the rise in the number of degree days. A degree day is defined as a unit of mean temperature representing 1° of difference from a standard temperature of 65°F used in calculating fuel consumption. If the mean temperature was 50°F then the calculation would be 15 degree days (65°-50°=15°).

Distillate oil heating degree days for the period July through December 1976 were 22% above normal and 35% above the level for the same period of 1975. Distillate oil heating degree days by PAD districts for the period July through December 1976 were as follows: PAD district I, 2,223.3 or 22% above

[7]Data are available for 1976 in the following Bureau of Mines Mineral Industry Surveys: Natural gas, Monthly; Natural gas Liquids, Monthly; and Petroleum Statement, Monthly; and also in the Bureau of Mines Minerals Yearbook 1976 Chapter on Natural Gas Liquids.

normal; PAD district II, 3,142.9 or 25% above normal; PAD district III 1,384.3 or 49% above normal; PAD district IV, 2,608.2 or 2% below normal; and PAD district V, 1,437.5 or 15% below normal.

RESIDUAL FUEL OIL

Reflecting needs accompanying a severe winter and a quickening in business activity, demand for residual fuel oil rose 13.5% in 1976 to 2.79 million bpd from 2.46 million bpd in 1975. The winter was the coldest in years. Most of the excess in degree days occurred in the final quarter of 1976 and in January 1977.

The use of residual fuel oil by utilities rose sharply in 1976 as the cold weather stimulated electric usage for heating. Increased demand for residual fuel oil also resulted from the movement of electricity generated from oil to normal coal generating areas with coal delivery problems. The shortage of hydropower is another contributing factor to increasing the demand for heavy fuel oil such as No. 5 and No. 6.

Domestic production of residual fuel oil increased 11.4% in 1976 to 1.38 million bpd from 1.24 million bpd in 1975. From a 30-year low of 706,000 bpd in 1970, production has been increasing steadily, and in 1976 established a new high. Nearly one-half of the 1976 production or 676,000 bpd was residual fuel oil of 1% or less sulfur content. In 1971, only 39% of production was 1% or less.

Imports in 1976 averaged 1.4 million bpd, a 14.3% increase over 1975. Some 658,000 bpd or 48.6% of imports were received into the States of Delaware, Maryland, New Jersey, Pennsylvania, and New York. About 472,000 bpd of imports had a sulfur content ranging from 0 to one-half (0.50%), and 262,000 bpd were destined for New York.

Although production and imports were up 13.2%, an increase in demand resulted in a moderate reduction in stocks to 72.3 million barrels by the end of 1976 compared with 74.1 million barrels at yearend 1975.

OTHER PRODUCTS

Petrochemical Feedstocks.—Some 164.4 million barrels of petrochemical feedstocks were produced by refineries in 1976, a 34.6% increase over the 1975 levels. Likewise, demand in 1976 rose 30.9% to 152.9 million barrels or 417,639 bpd. Naphtha-400° (less than 400° end point) accounted for 48% of demand, other feedstocks accounted for 40.6%, and still gas used for chemical or rubber manufacture, accounted for 11.4%.

Special Naphthas.—Special naphthas includes all finished products within the gasoline range that are specially refined to a specified flash point and boiling range for use as paint thinners, cleaners, and solvents. The special naphtha category also includes commercial hexane conforming with ASTM specification D-1836 and cleaning solvent conforming to ASTM specification D-484. Benezene, toluene, and xylene are considered in the special naphtha classification when they are blended into special naphtha stocks. Production in 1976 increased 19% to 89,200 bpd compared with 74,900 bpd in 1975. Exports in 1976 were double those of 1975, and domestic demand increased 9.5% in 1976.

Lubricants.—Demand for lubricants, after declining sharply in 1974-75, arrested the downtrend and increased 10.8% in 1976 to 152,273 bpd from 137,450 bpd in 1975. Exports in 1976 increased 4.2%. The 1976 production of 61.8 million barrels is 8.9 million barrels below 1974 (table 36).

There are 43 refineries in the United States with a finished lubricant manufacturing capacity of 226,900 bpd, according to a survey made by the National Petroleum Refiners Association. If the 168,861 bpd of production is equated against indicated capacity of 226,900 bpd, lubricant manufacturing facilities operated at 74.4% of capacity in 1976.

Waxes.—As a result of the pickup in economic activity, demand for waxes in 1976 increased 18.7% to 7.2 million barrels (19,700 bpd) from 6.1 million barrels (16,600 bpd) in 1975. There are 24 refineries in the United States with a finished wax capacity of 13,153 barrels per calendar day. In addition, these refineries and eight others have unfinished wax capacity of 12,089 bpd. During 1976, production of wax increased 23.7% to 7.0 million barrels of which fully-refined crystalline wax accounted for 45%; other crystalline accounted for 42%, and microcrystalline waxes accounted for 13%.

Wax is primarily a byproduct of lubricating oil manufacturing or at least of wax bearing crudes. Wax is found in varying amounts in crude oils. Paraffin base crudes and mixed base crudes, for example, contain both paraffins and naphthenes, they usually have a greater wax content than aromatic base crudes, and the type of wax recovered depends on the type of crude being refined. To improve the low-temperature pour point property of lubricating oils, the lubricant fraction of the crude is dewaxed and the byproduct from dewaxing is refined to obtain a finished wax. There are three broad classes of waxes: microcrystalline, fully-refined crystalline, and other crystalline (table 37).

Microcrystalline waxes are derived from the high-boiling lubricating oil fractions, and the other types are obtained from the intermediate boiling range lubricating oil fractions. Also, oil content is another characteristic. Fully-refined crystalline wax has an oil content of less than 0.5%. Microcrystalline waxes, because of their smaller crystal structure, have a greater affinity for oil than the crystalline type, and they are used extensively where there is a demand for tacky or ductile waxes such as for treating impregnating, coating, and filling electrical apparatus; and as a telephone cable filing compound.

Packaging provides the largest market for the crystalline waxes; important applications are hot melt coatings for frozen food overwraps, pouches, bags and envelopes; for coatings and impregnants for corrugated containers and folding cartons; and as coatings for paper cups. Nonpackaging uses are: Candles; crayons; floor, furniture, shoe, and automobile polishes; and cosmetics, pharmaceuticals, printing inks, explosives, carbon paper, and adhesives.

Petroleum Coke.—Petroleum coke is reported by the Bureau of Mines as catalyst coke and marketable coke. Catalyst coke is a noncommercial coke; it cannot be recovered commercially because it forms on the catalyst during the catalytic cracking of the charging stock in a refinery cracking unit. This carbon is burned off the catalyst in the regenerator section of a cracking unit, and the coke is used as a refinery fuel without ever being seen. However, production of catalyst coke is shown to complete a supply and demand balance for coke.

Production of both catalyst coke and marketable petroleum coke aggregated 130,145,000 barrels in 1976 or 1% above the 1975 volumes. About 52% of output was marketable coke and production in 1976 was 2% above 1975. Exports in 1976 were only nominally higher than in 1975 (table 38).

Only about one-third of exports is calcined coke and five countries, West Germany, Japan, the Netherlands, Norway, and Canada, accounted for 47% of the 12 million plus barrels exported. In the raw or green coke category, 25 million barrels were exported to foreign countries, and Japan and the Netherlands purchased more than half. There are three main outlets for marketable petroleum cokes; the domestic demand for raw coke as fuel, for calcined coke for the manufacture of carbon products such as electrodes and anodes, both baked and gravitized; for aluminum metallurgy, for brushes for electric motors and generators; and for specialties such as rings, seals and bearings, electronic, nuclear, and missile and jet propulsion parts. Coke can be gravitized by subjecting it to very high temperatures, and some refiners have developed premium automotive lubricating oils containing graphite made from petroleum coke. In 1976, total demand for marketable petroleum coke was 64,632,000 barrels. Of this, exports totaled 37,778,000 barrels and domestic demand accounted for the remaining 26,854,000 barrels. These data exclude 62,237,000 barrels of catalyst coke.

Asphalt and Road Oil.—A tapering off in the nationwide highway construction program, and a tightening in highway maintenance budgets of States, municipalities, and other political subdivisions affected demand adversely for asphalt and asphaltic products between 1973 and 1976. However, the decline curve appears to be flattening out; overall sales in 1976 of petroleum asphalt for consumption was less than 1% below the 1975 level, whereas in 1975 sales were 11.4% below the volumes sold in 1974.

Sales of asphalt paving products in 1976 were 21.5 million short tons or only about 118,000 short tons below 1975. Petroleum asphalt roofing product sales of 4,792,000 short tons in 1976 were a nominal 11,177 short tons less than in 1975. Likewise in 1976, similar small declines of 65,820 short tons occurred in sales of other products such as asphalts and fluxes.

Production of asphalt declined 3% in 1976 to 25.4 million short tons from 26.2 million in 1975, but with imports lower and demand down only about 1% it was necessary to drawdown on inventories. As a result, stocks at yearend 1976 were 3.5 million short tons or 15.0% below the 1975 yearend levels.

Road oil is a liquid asphalt of the slow-curing type and is classified by the ASTM as D-2026. Road oils may be derived from a blend of asphalt and oil which remain in a fractionator after the lighter ends such as naphtha, gasoline, kerosine, etc., are drawn off after straightrun distillation. Road oils, may be obtained, also, by blending asphalt cement with an oily fraction. In addition, there are two other types of liquid asphalt materials known as "cutback asphalts." The rapid-curing type (ASTM D-2028) is blended with naphtha and gasoline. The medium-curing type (ASTM D-2027) is blended with a lower vapor pressure material such as kerosine.

Still Gas.—Still gas is a mixture of extremely low-temperature boiling hydrocarbons produced during the distillation of crude oil and may be used as refinery fuel and/or as a petrochemical feedstock. During 1976, there were 180.7 million barrels used as fuel, a 3% increase from the 175.4 million barrels consumed in 1975. Consumption of still gas, used as a petrochemical feedstock, increased 11% in 1976 to 17.4 million barrels from 15.7 million barrels in 1975.

Miscellaneous Finished Oils.—The petroleum industry produces a variety of miscellaneous products that are sold directly to consumers or in bulk to specialty companies that package and distribute them under various trade names. Included in this category would be absorption oils, specialty oils such as hydraulic, insulating and medicinal oils, rust preventives, sand-frac, spray oils, and others. Also, synthetic natural gas (SNG) feedstock is included in this grouping. Production of miscellaneous finished oils in 1976 was about 47.2 million barrels, 46.5% over the 32.2 million barrels produced in 1975. Production of absorption oils decreased 8.3%, but the production of "other products" which includes SNG feedstocks, more than doubled from 11.1 million in 1975 to 25.4 million in 1976.[8]

Unfinished Oils.—Unfinished oils are oils that have been partly refined and will be further processed by refiners. Examples are: Naphtha, a light unfinished oil that is consumed primarily in the refinery itself to produce gasoline. About 90% of all naphtha use is in gasoline. Smaller amounts are used in the production of aromatics such as benzene, toluene, and xylenes. Also, small amounts are used in the production of specialty products such as hexane and special naphthas such as cleaners' solvents. In addition, small amounts are used as petrochemicals and synthetic gas feedstock. Gas oil, an unfinished oil, is heavier than naphtha and its major use is in the refinery to make middle distillate fuels (No. 294) and in the production of commercial jet fuel. Also small amounts are used in the production of lubricants and process oils. Aromatic gas oil, another unfinished oil, is a heavy residual oil derived from catalytic cracking of heavier oils for naphtha production. Its principal use is as carbon black feedstock. The rerun (net of unfinished oils) represents the receipts of domestic or foreign oil plus or minus changes in stocks (table 18).

TRANSPORTATION AND DISTRIBUTION

INTERDISTRICT MOVEMENTS

A vast transportation system consisting of pipelines, tankers, and barges and to a lesser degree, tank cars and tank trucks, move crude oil to refineries for processing into petroleum products. During 1976, refineries received 62.7% of their crude oil requirements by means of pipelines. Water transport, both tanker and barge, accounted for 35.7% and tank cars and trucks accounted for the remaining 1.6% (table 43).

Data collected on receipts of domestic and foreign crude petroleum at refineries in the United States show receipts from local production (intrastate), receipts from other States (interstate), and receipts of imported crude. These data, by method of transportation, indicate the final receipts by water, pipeline, tank car, and truck. Receipts of domestic crude by water usually are moved by pipeline from the point of production to the point of water shipment.

Refinery receipts of crude oil carried by tankers and barges totaled 1,758 million barrels or 4.8 million bpd in 1976. Some 84.6% of receipts by water was of foreign origin in 1976; in 1975 receipts were 78.3%. In 1972, foreign receipts accounted for 51.9%. A 5-year series of recipts is shown in table 43, and interdistrict movements by tanker and barge is provided in tables 44-45.

Domestic demand for petroleum products averaged 17.5 million bpd in 1976, a 6.9% increase over the 16.3 million bpd used in 1975. Demand in 1976 is broken down into PAD districts in table 14, and the 17 States comprising PAD district I accounted for 36.9% of domestic product demand. Foreign crude oil accounted for 89% of refinery output in district I. Of the remaining 11%, some 65,000 bpd were received primarily from district III (table 44).

[8]U.S. Bureau of Mines. Crude Petroleum, Petroleum Products, and Natural Gas Liquids, Mineral Industry Survey, April 1977, released September 1977, p.27.

There was a 47.7% increase in 1976 in the volume of foreign crude run by gulf coast refineries in district III. As a result, the volume of domestic crude run shrank to 69.2% from the 77.5% run in 1975 (table 20). However, gulf coast refineries continued to dominate, accounting for 42.6% of crude oil input to refineries in the entire United States.

A large part of refined product output by district III refineries is transported to other PAD districts and the interdistrict movement by tanker and barge of crude oil and major products, such as gasoline, jet fuel, distillate fuel oil, residual fuel oil, and other products such as lubricating oil, wax, and asphalt is shown in table 45. The magnitude of the tanker and barge movements of petroleum products from the gulf coast to the east coast in 1976 is indicated in table 45. The transportation of gasoline, jet fuels, kerosine, distillate fuel oil and natural gas liquids by pipelines between PAD districts is shown in table 46. During 1976, 1.6 million bpd or 69% of the motor gasoline output of refineries in district III was shipped to district I compared with 1.5 million bpd or 66% in 1975. Likewise, about two thirds of distillate fuel oil output in district III was used in district I in 1976.

Refined products produced at refineries in PAD district V in 1976 represented 88% of the domestic product demand for that district. Domestic crude oil, produced primarily in California, supplied 50% of refinery input and of the 50% of oil imported, 43% originated in Indonesia and 36% came from the Middle East, one-half of which came from Saudi Arabia. Canada, formerly an important supplier of crude oil for refineries in the Puget Sound area of Washington State, continues to phase out crude oil exports to the United States, as a result of actions taken by the Canadian National Energy Board (CNEB) in 1973. Imports of crude oil from Canada into district V in 1976 averaged 87,000 bpd compared with 163,000 bpd in 1975.

Under the original CNEB formula, crude oil exports to the United States would have been phased out by the end of 1981. But with the Sarnia-Montreal pipeline becoming operational Canadian crude oil exports to the United States except for heavy oil, will phase out by the late seventies. The Federal Government has indicated that for the next 5 years heavy oil production in excess of Canada's needs will be licensed for export.

The Canadian crude oil export phase out is having a drastic impact on "Northern Tier" refineries (those located in Washington, Montana, North Dakota, and Minnesota). This is discussed in another section of this chapter.

It is anticipated that the west coast will be unable to use all the oil available in PAD district V. This is understandable because Alaskan North Slope (ANS) oil is expected to be moving south through the Trans-Alaska pipeline to Valdez for tanker transport and become available for PAD district V by mid-1977. The pipeline is 800 miles long. Oil flow was at a rate of about 1.1 miles per hour so that the pipeline will be filled slowly at a rate of about 300,000 bpd. Providing there are no major complications, oil will arrive at the Valdez terminal by about the end of July 1977. Also, as a result of extensive drilling and development beginning in mid-1976, oil production from the naval petroleum reserve (NPR No. I), at Elk Hills, Calif., now exceeds 1 million barrels per month, and another source for oil over the longer term is the offshore fields in the Santa Barbara Channel. Both industry and Government estimates indicate that west coast refineries will be unable to absorb ANS production; therefore a sizeable surplus could develop by 1978, providing that Alaskan crude is not priced in such manner as to result in a shut-in of California production.

Although PAD district V could be a surplus area, there are crude oil deficient areas east of the Rocky Mountains in the Northern Tier States, the Midwest, midcontinent, and the gulf coast.

Two pipelines have been proposed to overcome these deficiencies. The first is the Long Beach to Midland, Tex., pipeline proposed by Sohio. Transportation Co. (Sohio). This line would run from a tanker unloading facility in the Port of Long Beach, Calif., across Southern California, Arizona, and New Mexico to Midland, Tex., and it would require about 250 miles of new pipeline and the conversion of a natural gas pipeline in California. In addition, about 670 miles of existing natural gas pipeline, owned by the El Paso Natural Gas Co. (EPNG), would be leased to Sohio and converted to transport crude oil eastward to Midland, Tex. From the Midland area, an extensive crude oil distribution system running north, east, and south is already in place aggregating a capacity of some 2 million bpd. Work on the Sohio project awaits the approval of the State of California.

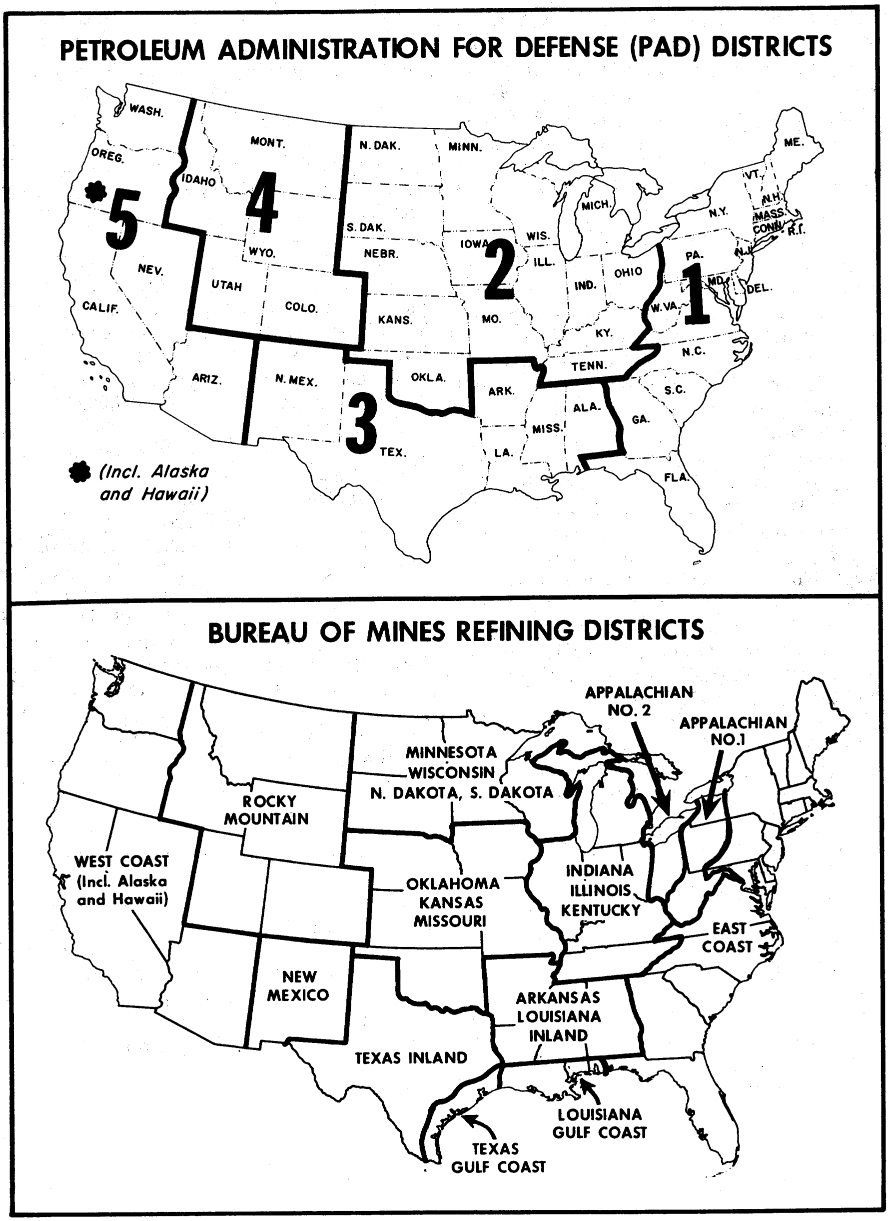

Figure 5.—Maps of Petroleum Administration for Defense (PAD) districts and Bureau of Mines refining districts.

Concern over the potential decrease in air quality in the Los Angeles, Calif., basin is the largest stumbling block to granting the permits needed to start work on this project.

The Northern Tier pipeline proposal would transport Alaskan oil by means of a 1,570-mile line from Port Angeles, Wash., to Clearbrook, Minn. The pipeline route from Port Angeles would skirt the Olympic National Park and pass through the Coeur d' Alene area of Idaho. In Montana, the route would run southeast to the Helena area, eastward into North Dakota, and on to Clearbrook, Minn. The proposed route has been selected for environmental acceptability. Also, more than one-fourth of the route would be over railroad rights-of-way.

Refineries in the six States which make up the Northern Tier have a crude oil throughput of about 840,000 bpd. Throughput of Washington refineries account for 285,000 bpd, and more than 200,000 bpd is foreign oil other than Canadian. Only about 60,000 bpd is imported to Washington refineries from Canada. Canadian oil imported in the other five States averaged about 280,000 bpd in 1976, and Minnesota accounted for one-half of that volume.

PIPELINES

Crude oil pipelines delivered 3,086 million barrels or 8,431,000 bpd to refineries in 1976, a slight increase from the 8,384,000 bpd in 1975 (table 43). Petroleum product pipelines delivered 3,662.1 million barrels, or an average of 10,005,737 bpd in 1976, compared with 3,272.2 million barrels, or 8,965,000 bpd in 1975. Transportation by pipeline of petroleum products between PAD districts is shown in table 46. Transportation and stocks in lines and working tanks is available in table 47; tariff rates are shown in table 48.

Pipeline Costs.—The Trans-Alaska pipeline was a major contributor to rising pipeline construction costs. Reasons for higher cost can be traced to new stronger stress-level codes requiring stronger pipe to meet more demanding specifications. The more expensive grades of steel and inspection cost are borne by the contractor and the company. Other items such as pumping units, both motor- and engine-driven power units, increased in cost during 1976. Actual construction and major cost items were up in 1976. The increase of the past 2 years, 1974 through 1975 was 22.9%, but between 1975 and 1976, the increase was only 5% according to the construction cost index of the Interstate Commerce Commission.

RAIL, TANK TRUCK, BARGE, AND TANKERS

The annual study of the Association of Oil Pipelines estimated that the total tonnage of crude oil and petroleum products carried was 1,831 million short tons in 1975. Of this, 48.02% was transported by pipelines, 22.06% by water carriers, 28.42% by motor carriers, and 1.5% by railroads. The overall volumes transported in 1975 were about 1% below that of 1974. Petroleum products accounted for two-thirds of the volume transported in 1975.

Product pipelines transport only the light products such as gasoline, light fuel oils, heating oils, LPG, kerosine, and jet fuel. These lines transported 424.7 million short tons or 34.8% of the total. Motor carriers transported some 444.4 million short tons or 36.4% of the petroleum products carried. In terms of billions of ton miles, the total aggregated was 846.7 billion, of which 59.9% was transported by pipelines, 35% by water carriers, 3.26% by motor carriers, and 1.66% by railroads. Total crude petroleum carried in domestic transportation, in billions of ton miles was 331.5 in 1975; pipelines accounted for 86.9% and water carriers accounted for 12.2%.

Deepwater Ports.—A tanker voyage from the Middle East to the U.S. east coast involves a 24,000-mile round trip, and many tankers in use today are very large crude carriers (VLCC's), and virtually all of these ships are unable to enter ports with depths under 75 feet. At present, there are no U.S. ports capable of accommodating VLCC's with capacities greater than 200,000 deadweight tons (dwt). The deepest ports in the United States are on the west coast and they can handle tankers up to 150,000 dwt. Most harbors in the United States are limited to ships with capacities ranging from 40,000 to 70,000 dwt.

The Deepwater Port Act of 1974, signed by the President in January 1975, provided for licensing and regulation of deepwater ports. The Secretary of Transportation is empowered to grant licenses for ownership, construction, and operation of deepwater-port facilities. At the same time, a Governor of an adjacent State could veto the project.

Two corporations, formed by groups of companies, proposed to construct two such ports: One 31 miles off the Louisiana coast at Grand Isle in water over 100 feet deep in the Gulf of Mexico, and the other off the Texas coast. In the Louisiana Offshore Oil Port (LOOP), the corporation proposes to store imported oil in the Clovelly salt dome near Galliano, La. The proposed storage capacity of this facility is expected to be about 56 million barrels of oil. The second deepwater terminal (Seadock) is to be constructed off the upper Texas gulf coast south of Freeport. The storage facilities for Seadock would be located 5 miles inland and would consist of 28 tanks with a storage capacity of 22.5 million barrels.

Oil off-loaded at such terminals would be transported by pipeline to shore thereby reducing the need to transfer oil cargoes from VLCC's to smaller vessels for transport to conventional terminals or refineries.

Both applications are being considered by the Department of Transportation (DOT), the agency authorized to issue licenses to build and operate deepwater terminals. If the permits are granted by mid-1977, the two terminals were expected to be online by 1980. Unlike LOOP, however, Seadock has run into difficulties. Four large participating oil companies have withdrawn from this project as the license provisions involving proposals by DOT, the antitrust division of the Department of Justice, and the Federal Trade Commission are considered to be too stringent and too restrictive.

Meanwhile, the Texas Legislature has enacted superport legislation that would enable the State of Texas to establish a terminal for large tankers off the Texas coast in the event the remaining Seadock project participants decide against obtaining a license. Under the bill, the State would finance the deepwater port by issuance of revenue bonds.

In addition to these offshore deepwater ports, the Port of Corpus Christi expects to bring into being the first onshore supertanker facility to the Gulf of Mexico. The U.S. Army Corps of Engineers is now completing work on an environmental impact study of the proposed facility.

TANKER RATES

Tanker charter rates, after reaching a peak late in 1973, have been in a downtrend. From $2.02 per barrel, charters in December 1973 for 34° crude oil for Large Range 2 tankers (from 80,000 to 159,999 dwt) by November 1975 dropped to $1.26 per barrel, for cargoes destined from Ras Tanura to New York by way of the Cape of Good Hope, rates firmed up during the severe 1975-76 winter, but at the end of 1976 the rate per barrel had declined to $1.18. Charters, same destination, for vessels of 16,000 to 24,999 dwt, which are classified as "general purpose" tankers, dropped over the same interval from $3.23 per barrel to $2.90 per barrel. By the end of 1976, the rate for the smaller tankers, however, had rebounded to $3.12 per barrel.

An oversaturation in tanker supply, particularly the larger tankers, has weakened tanker rates.

STOCKS

Stocks of crude oil, natural gas liquids and refined products have been expanding after reaching a low point of 866.9 million barrels in February 1973. Crude oil stocks, which were 242.5 million barrels at yearend 1973, had climbed to 285.5 million by yearend 1976, a 43-million-barrel or 17.7% difference. Stocks of refined products reflect the impact from the lack of natural gas and the substitution of fuel oils and liquefied petroleum gases for fuels. As a result, stocks at yearend 1976 were well below a year earlier (table 49).

As a result of very heavy drawdown of petroleum products such as distillate fuel oil and residual fuel oil, stocks of products at yearend 1976 were 707.7 million barrels, 40.1 million barrels or 5.4% below the December 1975 levels. However, stocks of crude oil and lease condensate at yearend 1976 were 285.5 million barrels or 5.2% higher than at yearend 1975 (table 50). Thus, continuing the growth from the 7-year low point of 235.4 million barrels at the end of February 1973.

STRATEGIC PETROLEUM RESERVES AND STORAGE SITES

The Strategic Petroleum Reserve plan has been setup to reduce the impact of an interruption of imports, if one occurs, such as the Arab Oil Embargo of 1973-74. Congress enacted legislation to establish a Stragegic Petroleum Reserve (SPR) in Title I, Part B of the Energy Policy and Conservation Act of 1975 (EPCA), Public Law 94-163.

Strategic Storage.—Under the initial phase of the SPR, referred to as the Early Storage Reserve (ESR), 150 million barrels of oil are to be stored by 1978, and storage will start initially at 40,000 to 50,000 bpd. Of the different storage sites picked, the one's to be used for the ESR are; Bryan Mound in Brazoria County, Tex.; West Hackberry in Cameron Parish, La.; and Bayou Choctaw in Iberville Parish, La.

Under the EPCA, the FEA is directed to pick eight sites for the SPR program. With the three sites previously listed, the other five sites are Cote Blanche Island mine, St. Mary's Parish, La.; Weeks Island mine, Iberia Parish, La.; Kleer salt mine, Van Zandt County, Tex.; Central Rock mine, Fayette County, Ky.; and Ironton mine, Lawrence County, Ohio.

The storage facilities sought are existing solution-mined salt dome cavities because of the relative low cost of bulk storage for petroleum and the extreme geological stability of the rock salt masses.

FEA had asked for a 500-million-barrel storage plan, but the President suggested that the reserve storage capacity be doubled to 1 billion barrels.

PRICES

Crude Oil.—The actual domestic average price of crude oil in the United States rose from $7.87 per barrel in February 1976, to $8.62 or a 9.5% increase according to the FEA. Prior to February 1976, the domestic crude petroleum wellhead price represented an estimate of the average of posted prices. After February 1976, however, the wellhead price represents an average of first-sale prices.

The average value of domestic crude oil at the wellhead, which was $3.39 per barrel in 1971-72, increased to $3.89 in 1973, $6.74 in 1974, $7.56 in 1975, and $8.18 in 1976. These increases, which began in 1973, were the result of an effort by the Cost of Living Council (CLC) to stimulate domestic crude oil production. On August 17, 1973, the CLC enacted a two-tier pricing system under phase 4 oil regulation. The system released from ceiling prices "new oil" (oil produced above 1972 levels) and made an adjustment for the remainder of current production. The price of new oil produced, which had not been covered by the price ceiling, rose steadily to market levels. The ceiling price for domestic crude was about $1 per barrel below the world price at the time phase 4 rules were issued on August 17, 1973. Since then, however, world prices have increased sharply and so have prices for upper tier domestic oil.

The price-regulating function of CLC was absorbed by the FEA in 1974. Between January and December 1974, the price per barrel rose 13% from $9.82 to $11.08. The price of old, or controlled, oil rose nearly 35% from $3.90 per barrel in August 1973 to $5.03 (revised) in December. Subsequently, the FEA revised its calculations and the price of old oil was reduced from $5.25 per barrel to $5.03 per barrel. The following tabulations show prices per barrel at the wellhead for old and new crude petroleum for the last month of each quarter in 1975. April 1977 prices are shown to illustrate the impact of EPCA after January 1976. Domestic crude petroleum prices per barrel have climbed from a 1975 average price of $7.67 to a 1976 average price of $8.14 or 6%.

	Old	New	Domestic average
1974:			
Average	5.03	10.13	6.87
1975:			
March	5.03	11.47	7.57
June	5.03	11.73	7.49
September	5.04	12.46	7.75
December	5.03	12.95	7.93
Average	5.03	12.03	7.67

	Lower tier	Upper tier	Stripper	Domestic average
1976:				
March	5.07	11.39	--	7.79
June	5.15	11.60	--	7.99
September	5.17	11.65	13.21	8.39
December	5.17	11.64	13.30	8.62
Average	5.13	11.69	13.29	8.18
1977:				
January	5.17	11.44	13.27	8.50
April	5.15	10.97	13.28	8.40

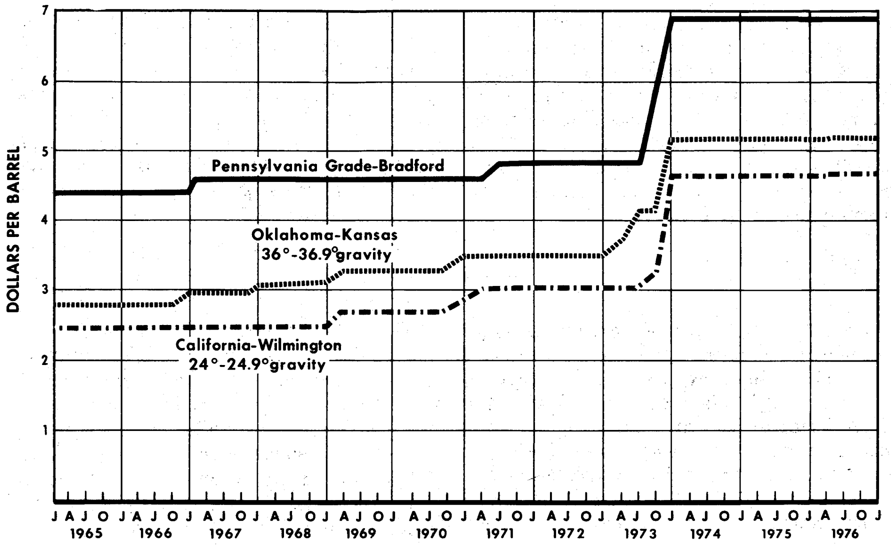

Figure 6.—Posted prices of selected grades of crude petroleum.

The FEA revised the designations used in pricing. The "old oil" title changed to "lower tier" and stripper well produced oil was released from price controls. "Upper tier" refers to the same oil as the former designation "new oil."

Crude oil imports supplied about 30% of crude oil requirements in 1976, and with prices climbing the refiners acquisition costs have followed suit. This cost to the refiner is the average of domestic and imported crude costs and represents the amount of crude cost which the FEA permits refiners to pass on to their customers.

A composite of refiner's acquisition costs of imported and domestic crude was $3.85 per barrel in May 1973, had climbed by December 1976 to $11.32 per barrel, nearly a threefold increase. The rise was due primarily to the increase in the cost of imported oil. The refiner's acquisition cost for imported oil rose from $3.92 per barrel in May 1973 to $13.71 per barrel by December 1976. That trend continues upward as evidenced in the tabulation for refiner's acquisition costs.

The following tabulation shows refiner's acquisition cost per barrel for imported oil, domestic oil, and a composite of both as maintained by FEA:

	Domestic	Imported	Composite
1974:			
Average	7.18	12.52	9.07
1975:			
March	8.38	13.28	9.91
June	8.33	14.15	10.33
September	8.49	14.04	10.79
December	8.66	14.81	10.98
Average	8.39	13.93	10.38
1976:			
March	8.48	13.51	10.44
June	8.60	13.48	10.88
September	8.95	13.47	11.08
December	9.25	13.71	11.32
Average	8.84	13.48	10.89
1977:			
January	9.23	14.11	11.64
April	9.34	14.35	11.82

Entitlements.—Subsequent to adoption of the two-tier pricing system, in November 1974 FEA initiated the entitlements system under the Old Oil Allocation Program (CFR 211.67). Every refiner had to have an entitlement to process a barrel of old crude oil as a percentage of total crude processed (that is, the total runs to stills) of old oil, imported oil, and domestic exempted oil. The price of an entitlement fixed by FEA, is defined as the exact differential as reported for the month between the weighted average delivered cost per barrel to refiners of both imported crude oil and stripper crude oil, and the weighted average delivered cost per barrel to refiners of old oil, less 21 cents. Each month, FEA calculated the amount of old oil produced as a percentage of total crude oil processed. If, for example, the old oil ratio was 40% and a refiner's old oil ratio was 60%, this refiner would have to buy entitlements equal to 20% at prices set by FEA from those refiners with less than 40%. An entitlement purchased at $5.00 would entitle the purchaser to process 1 barrel of old oil at about $5.03 per barrel, so that the effective cost would be about $10.03 per barrel for the 20% over the old oil ratio.

The Energy Policy and Conservation Act (EPCA) amended the Emergency Petroleum Allocation Act of 1973 (EPAA) by adding a new section that setforth a "new" crude oil pricing policy, which required the President to adopt implementary regulations designed to result in the maximum weighted average first-sale price during the month of February 1976 of $7.66 per barrel, as stipulated in the EPCA. In subsequent months, the EPCA permitted adjustments in the first-sale price of domestic crude to take into account the impact of inflation and as a production incentive. For example, if current production from a property exceeds 1972 base production control levels (BPCL) for the property, the excess production qualifies under the new regulations as upper tier crude oil. In 1976, however, the FEA clamped ceilings on crude prices and the freeze continued into 1977. The impact of this freeze in 1976, is shown in table 55.

Data on prices of selected crude oils and products are given in tables 56-57.

In the United States, gasoline outweighs all other products in terms of volume produced and relative importance in the refinery mix. Prices of gasoline have continued upward along with rising crude oil prices. The average service station price of regular-grade gasoline (including taxes) has risen from 42.26 cents per gallon as of December 1, 1973, to 53.15 cents per gallon on December 1, 1974, to 59.42 cents per gallon on December 1, 1975, and to 60.61 cents per gallon on December 1, 1976, according to Platt's Oil Price Handbook and Oilmanac, 1976 edition.

Shown in the following tabulation (in dollars per 100 gallons) are some comparisons in selected cities of prices of No. 2 home-heating oil between the 1972 yearend and January 1977. These intervals indicate the impact of the pass-through policy on retail prices. Between January 1974 and January 1977 the U.S. average rose 38% from $32.89 to $45.42 per 100 gallons.

Standard metropolitan statistical area	December 1972	January 1974	January 1975	January 1976	January 1977
U.S. average	$19.72	$32.89	$37.84	$41.46	$45.42
Baltimore	19.33	31.18	36.60	41.02	45.12
Boston	20.40	32.90	40.06	42.49	45.06
Chicago and Northwestern Indiana	18.65	31.66	33.96	43.73	43.54
Detroit	18.62	30.35	35.75	39.68	44.75
Milwaukee	18.93	31.23	36.58	40.07	45.58
Minneapolis - St. Paul	18.06	34.74	35.72	40.13	44.91
New York and Northeastern New Jersey	20.40	36.90	40.04	34.82	47.71
Philadelphia	19.23	31.30	37.96	43.52	45.03
St. Louis	19.49	33.72	37.91	40.98	44.62
Washington, D.C	19.78	33.30	40.82	41.99	47.09
Seattle	22.17	33.50	38.20	44.93	47.32

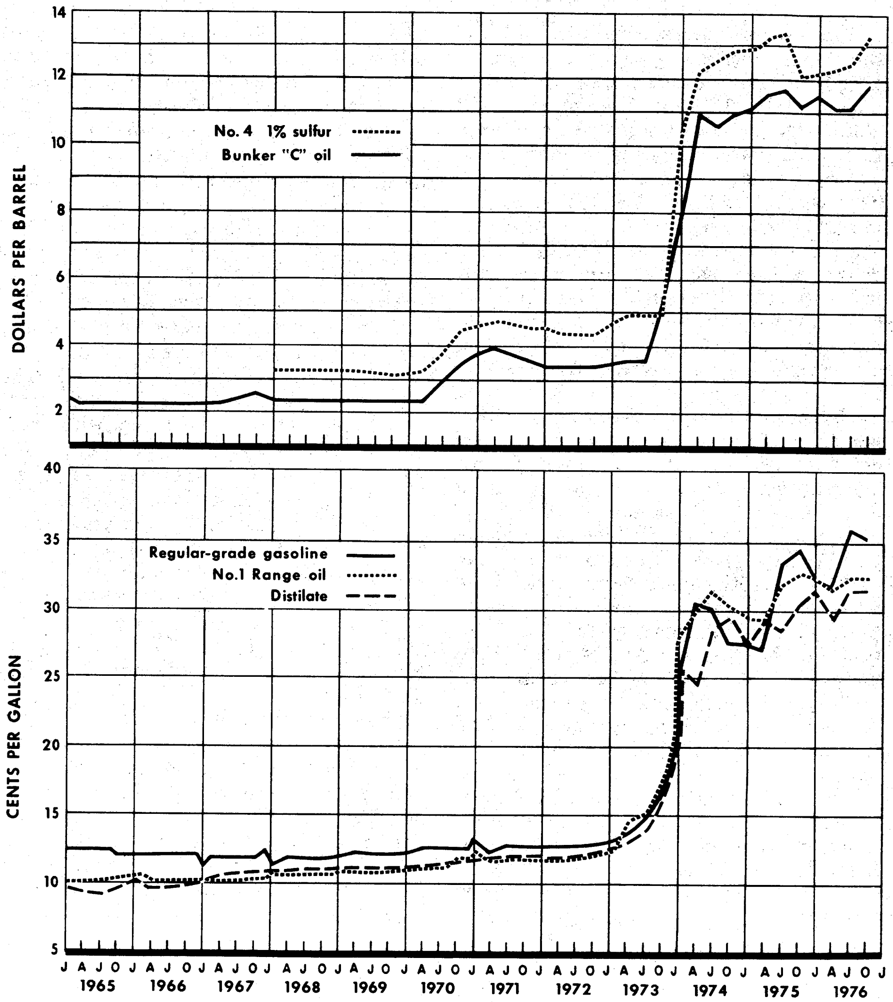

Figure 7.—Quarterly prices of Bunker "C" and No. 2 distillate fuel at New York Harbor, No. 1 range oil at Chicago district, and regular-grade gasoline at refineries in Oklahoma, by quarter.

Residual Fuel Oil Prices.—The price of Bunker "C" fuel oil at New York Harbor has been in an uptrend since 1972; from $3.45 per barrel at yearend 1972, to $5.42 per barrel by December 1973. By December 1976, the price was $11.85 per barrel. The trend of Bunker "C" prices for 1968-76, inclusive, is shown in figure 7.

Unlike the use of Bunker "C" fuel, use of No. 6 residual fuel oil is restricted to 0.3% sulfur in many communities along the eastern seaboard, New York City is an example. The average price per barrel for 0.3% sulfur No. 6 fuel oil high pour in the New York Harbor cargo market since 1972 follows:

1972	$3.33
1973	6.48
1974	14.60
1975	12.03
1976	12.49

The price at yearend 1976 was $14.35 per barrel for No. 6 high pour, 0.3% sulfur.

FOREIGN TRADE

Exports.—Exports, which comprise only 1.3% of total demand, totaled 81.6 million barrels in 1976 or an average of 223,000 bpd. This is an increase of 6.5% over 1975 when exports averaged 209,000 bpd. Virtually all of the 2.9 million barrels of crude exported was destined for Canada and Puerto Rico. In the products category, some 78.7 million barrels or 215,000 bpd were exported and petroleum coke accounted for 46% of petroleum exports. Coke, which is a surplus commodity in the United States, is sent primarily to Japan, the Netherlands, West Germany, and Canada where it is used extensively in the metallurgical industries of these countries.

Lubricants from the United States are shipped to virtually every country throughout the world, and in 1976 there were 9.5 million barrels exported from the United States. Lubricant exports from the United States, however, have been in a downtrend because new refineries constructed in foreign countries included facilities for the manufacture of lubricating oils and greases; hence, a shrinkage in the market for products from the United States. In 1967, for example, exports for lubricants averaged 50,866 bpd compared with 25,943 bpd in 1976.

Exports of petrochemical feedstocks in 1976 accounted for 11,144,000 barrels or 13.7% of shipments to foreign countries. Included in this category are carbon black feedstock oil, naphtha of less than 400° F end point, and many other unfinished hydrocarbons suitable for petrochemical manufacture. Exports of liquefied gases totaled nearly 9,000,000 barrels and were shipped primarily to Mexico from Texas by truck transports.

Imports.—Reflecting an increase in refining activity, imports of crude oil in 1976 rose 29.2% to 1.9 billion barrels or nearly 5.3 million bpd. In the products category, imports were lower for most products except kerosine, residual fuel, and butane and propane. An increase of 177,400 bpd in residual fuel oil imports more than offset sharp reductions in imports of gasoline and declines in imports of distillate fuel oil and jet juel. Saudi Arabia supplied more than 1.9 million bpd or 23% of crude imports, and Nigeria followed with about 1 million bpd or 19%. Indonesian oil ranked third with 536,000 bpd or 10%, and most of this oil was landed in 1976 in PAD district V for use by west coast refineries. About one-third of all crude oil imports or nearly 1.8 million bpd was received at gulf coast ports in PAD district III, and more than one-half of that crude oil was obtained from two countries; 542,600 bpd originated in Nigeria and another 456,400 bpd were imported from Saudi Arabia. Nearly 138,000 bpd were obtained from Algeria and imports from Libya into PAD district III averaged about 153,000 bpd.

Even more important to crude supply are imports of foreign crude into PAD district I. During 1976, imports of crude averaged 1.4 million bpd, a volume equivalent to 89.2% of the crude oil import to refineries in PAD district I in 1976. More than one-half of imports came from Saudi Arabia and Nigeria. Algeria and Venezuela supplied another 25% of the requirements.

Imports of petroleum products averaged 2 million bpd and residual fuel oil accounted for 1.4 million bpd or nearly 7 out of every 10 barrels of products imported. Venezuela supplied nearly one-third of the residual fuel oil imported into district I, and the Virgin Islands and the Netherlands Antilles combined imports supplied another 36%. Imports of residual fuel oil were received in district I from 37 countries of origin in 1976 and reflects the rising demand which accompanied the severe winter weather in the Midwest and the Northeast. Also, the lack of natural gas triggered increased use of fuel oils as a substitute fuel in 1976.

Some 49 million barrels of distillate fuel oil averaging 134,000 bpd were imported into district I, and 62% of this volume was received from the Virgin Islands. Likewise, of the 146,190 bpd of motor gasoline imported into district I, 60% came from the Virgin Islands and another 29% came from Puerto Rico.

In the aggregate, imports of both crude oil and products averaged 7,395,000 bpd in 1976. Of this volume 6,111,000 bpd was received from all Organization of Petroleum Exporting Countries (OPEC) sources, and 3,323,000 bpd was received from OPEC Middle East and North Africa as indicated in figure 8. It should be noted, however, that not all of these imports were received directly from OPEC. For example, in the petroleum products group some 1,050,000 bpd of petroleum products were derived from OPEC crude processed in refineries

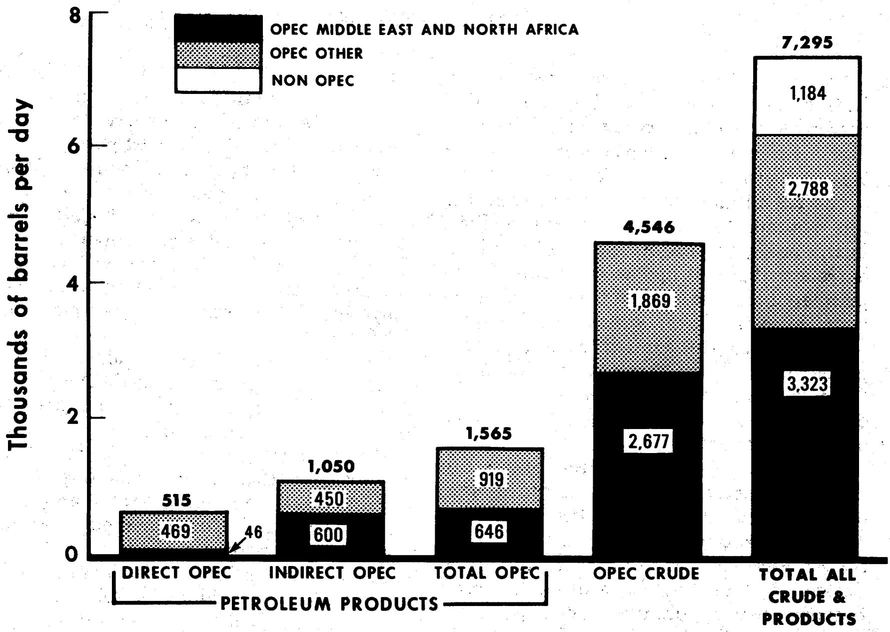

Figure 8.—Imports, direct and indirect, from OPEC Nations.

located primarily in the Virgin Islands and in Puerto Rico. Only 515,000 bpd of products were recovered directly from OPEC countries.

The OPEC consists of 13 countries, 6 of these are in the Middle East: Iran, Iraq, Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates. Africa includes four countries: Algeria, Gabon, Libya, and Nigeria. Ecuador and Venezuela constitute the two countries in South America, and Indonesia in Asia completes the group.

Production of oil has been declining in the United States since 1970, creating a dwindling domestic supply. Meanwhile, demand continues to trend upward; hence, the need for greater imports. In 1976, imports equaled 41% of demand, whereas in 1970 when crude production peaked, imports accounted for only 24%. Furthermore, products made up more than one-half (57.9%) of total imports and residual fuel oil accounted for 77% of the products segment.

WORLD REVIEW

OPEC, which accounts for 90% of all crude oil in international trade, established the price of Arabian marker crude at $12.38 per barrel as the posted price[9] and $11.51 per barrel as the sales price in October 1975. These prices remained unchanged through yearend 1976. At the OPEC ministerial conference in December, price increases as high as 25% were proposed for January 1, 1977; however, Saudi Arabia, which currently produces about one-third of all OPEC output directed its influence in favor of price moderation. The Saudi Arabian Government declared its motive in adopting a price restraint policy as primarily an act of faith with the West to encourage their support in resolving the Arab-Israeli conflict.

The December OPEC meeting was finally concluded with the adoption of a two-tier structure of oil prices effective January 1, 1977. Eleven members of OPEC increased the price of marker crude by $1.19 per barrel or 10.3%, while Saudi Arabia and the United Arab Emirates raised the price of marker crude by $0.58 per barrel or 5%. Prior to this dispute, Saudi Arabia, as flexible producer, was able to minimize competition among OPEC members. When demand for OPEC crude was weak in the recession of 1974-75, Saudi Arabia made major cutbacks in oil production with the objective of preserving the cartel and maintaining high price levels. With revenue requirements far below receipts, the Nation could tolerate reduced exports. By the adoption of the lower tier price level, Saudi Arabia had reversed its role. Saudi Arabia announced plans to increase production and force the upper tier producers to cutback production in face of their market disadvantage. The longevity of the two-tier pricing structure is subject to the supply-demand outlook for OPEC oil in 1977 as well as the frequently shifting political climate.

Production.—World crude oil and field condensate production averaged 57.9 million bpd, a record level surpassing the previous high recorded in 1974 by 1.6 million bpd, and surpassing output in the deep recession year of 1975 by 4.5 million bpd. For the first 9 months of the year production averaged only 56.5 million bpd but surged to an average of 61.3 million bpd in the last quarter. Increased demand at yearend was prompted by stockpiling as buyers took advantage of the comparatively cheaper prices still in effect before the announced price increases of January 1, 1977.

The U.S.S.R. maintained its leading position among world producers accounting for 10.4 million bpd, followed by Saudi Arabia with its share of Neutral Zone production averaging a total of 8.6 million bpd, and the United States with production averaging 8.1 million bpd. For additional production figures on a country-by-country basis refer to table 62.

More than half of the world output was derived from the 13-member States of OPEC producing a combined average of 30.8 million bpd, for calendar year 1976 and surging to an average of 34.3 million bpd for the month of December, preceding the price increases of the new year.

Combined production from non-OPEC Nations averaged 27.1 million bpd an increase of 0.9 million bpd over 1975. While much of this increase in production was attributed to output from the U.S.S.R., production from the North Sea averaged over 0.5 million bpd in 1976, about 300,000 bpd over 1975 levels. By 1977, North Sea production should increase by approximately 1 million bpd over 1975 output leading the non-OPEC world in production growth by volume.

Crude Oil Movements.—Crude oil constitutes about 80% of all Western European petroleum imports, 88% of Japanese petroleum imports, and 75% of petroleum imports of the United States. Crude oil movements to these major markets totaled nearly 22 million bpd in 1976. Nearly 60% of these imports were obtained from the Middle East. Excluding intra-European shipments, Western European total crude imports averaged 12.1 million bpd with the Middle East supplying 71% or 8.6 million bpd. The Middle East supplied 79% of Japanese crude imports or more than 3.6 million bpd. United States crude petroleum imports approached 5.3 million bpd, about 35% or near 1.9 million bpd was supplied by the Middle East. Saudi Arabia supplied more than 1.2 million bpd. Other major U.S. crude suppliers were Nigeria with 1 million bpd and Indonesia at 0.5 million bpd.

[9]Price used for calculating producing companies' tax and royalty payments on equity oil.

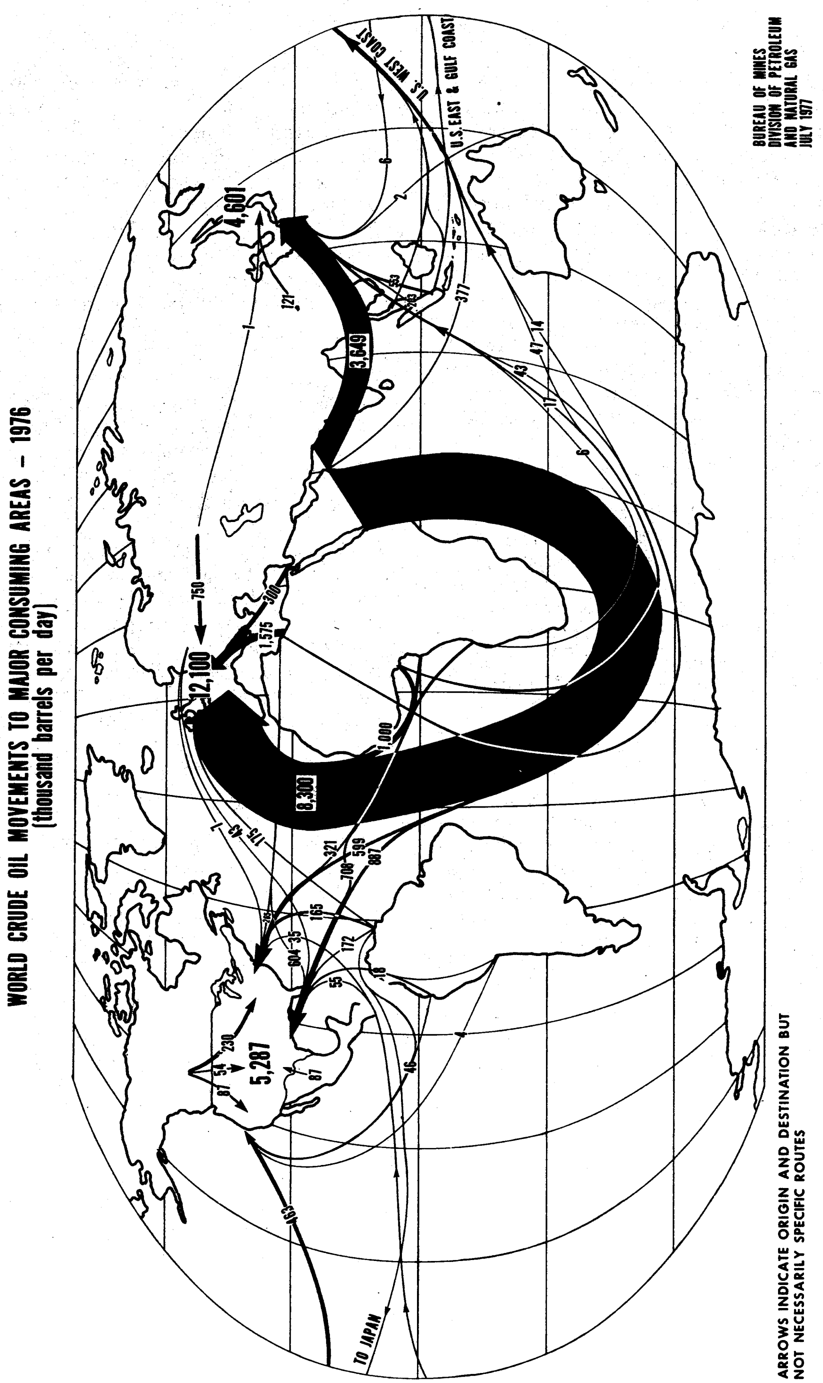

Figure 9.—World crude oil movements to major consuming areas, 1976.

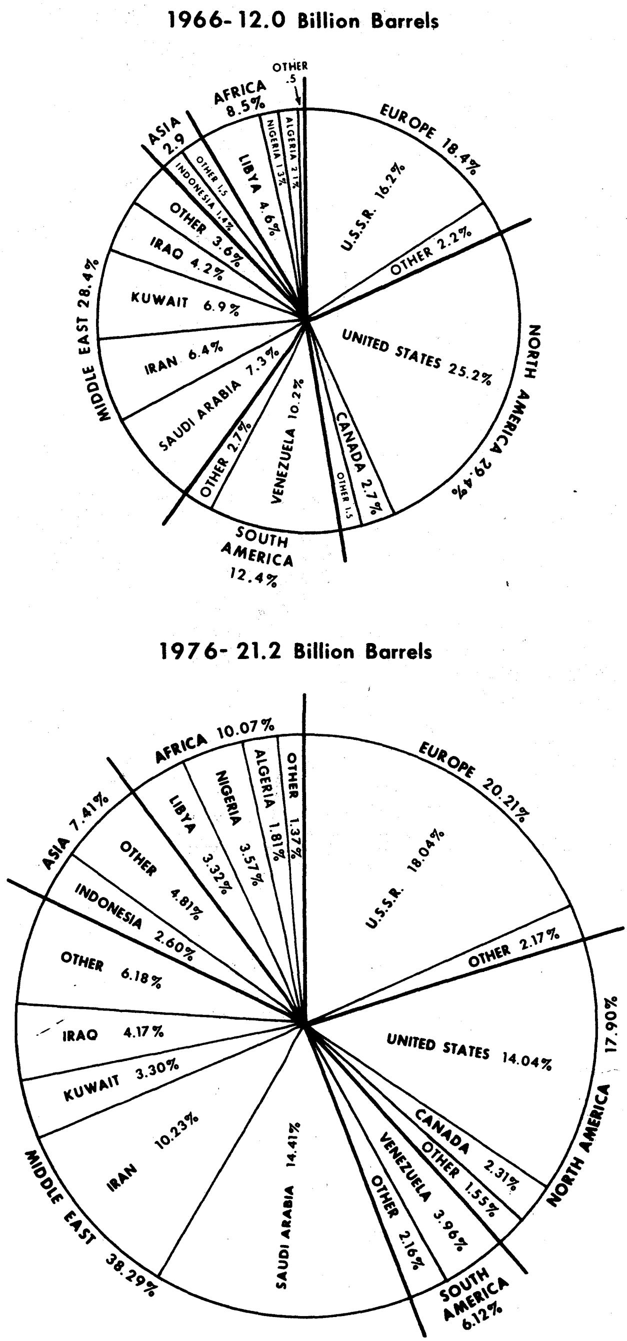

Figure 10.—World share of crude oil production, in 1966 and 1976.

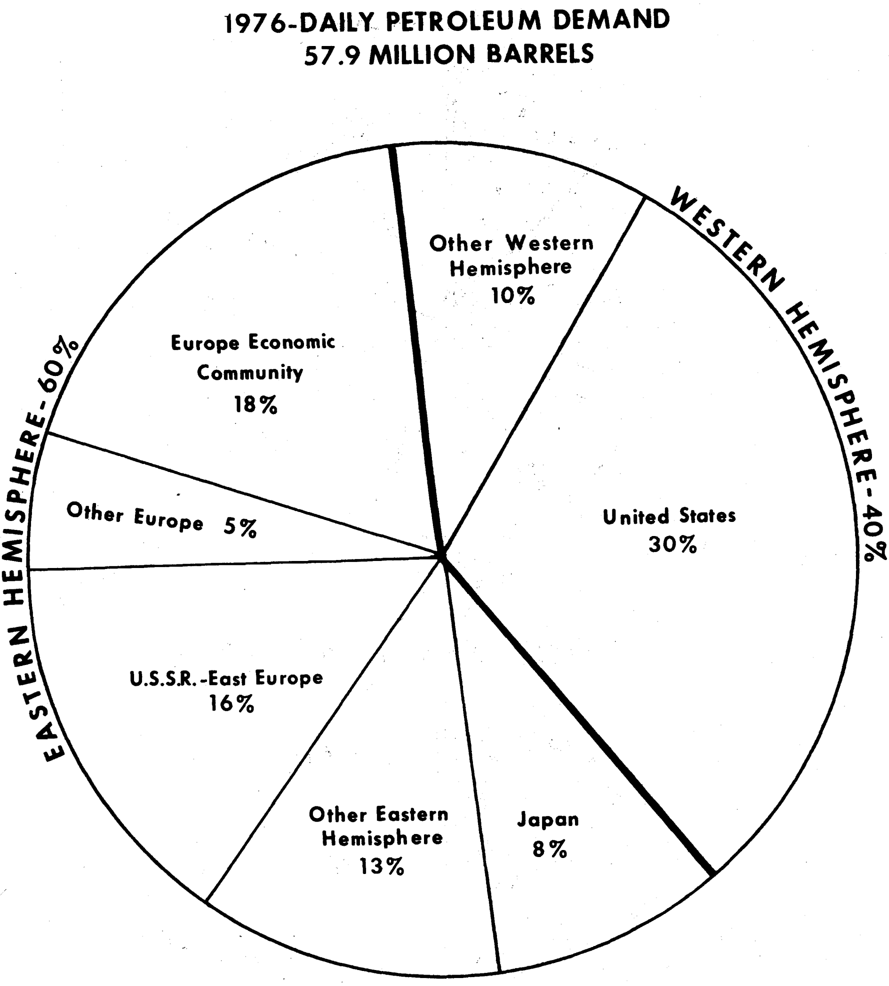

Figure 11.—World daily petroleum demand, 1976.

Transportation.—With the exclusion of nearly 46 million dwt in combined carriers, the world tanker fleet totaled 321 million dwt at yearend 1976 representing a net increase, after losses, scrappings, and conversions, of 29 million dwt over the previous year. Over 31% of the world tanker tonnage sails under the Liberian flag followed by registries in Japan and the United Kingdom, which account for 10% and 7%. Tankers over 200,000 dwt and up to 285,000-dwt capacity constitute 43% of the total tanker fleet. Since the closure of the Suez Canal in 1967, most of the new tankers under construction were in this capacity range. In 1976, however, of the 40.4 million dwt of newly commissioned tanker capacity, 13.5 million dwt was in the range of over 200,000 dwt and up to 285,000 dwt, while 14 million dwt was in the range of 285,000 dwt and over.

Voyages from the Middle East occupied 78% of the oceangoing fleet. Voyages from the Middle East to Europe alone occupied 41% of the total oceangoing fleet, while voyages between the Middle East and Japan occupied 11%, and voyages between the Middle East and the United States occupied 9%. Movements on the Mediterranean Sea were reduced when Iraq discontinued exports from Banias and Tripoli in April. The Saudi Arabian crude exports through the

Tapline terminal at Sidon had been discontinued in 1975 and were not renewed during 1976. Movement through the Suez Canal in 1976 was limited to laden tankers of no more than 70,000 dwt. Laden tankers transiting the Suez Canal totaled an estimated 35 million dwt in 1976. Tankers returning to the Persian Gulf in ballast totaled an estimated 100 million dwt in 1976.

Two new Middle Eastern pipelines should be operational in 1977; the Sumed pipeline connecting the Gulf of Suez with the Mediterranean Sea and the Iraq-Turkey pipeline connecting the Iraq oilfields to the Mediterranean outlet of Dortyal. When these pipelines are operational, Mediterranean tanker traffic will significantly increase. In 1977 the Trans-Alaska pipeline will be operational increasing tanker activity along the North American west coast and through the Panama Canal.

Five United States west coast ports can accomodate tankers of 100,000 dwt or better. The largest of these is at Ferndale, Wash., accomodating tankers up to 150,000 dwt. Most United States gulf coast and east coast ports, while serving the more heavily populated areas of the United States, can only accomodate tankers of 50,000 dwt or less. Without lightering and transshipment facilities, importers could not benefit from the economic advantages realized in using very large crude carriers for long distance hauls. Transshipment terminals, operating at Curacao and at the Grand Bahamas Island, were joined in 1976 by the new Bonaire terminal in the Netherlands Antilles. The construction of two superports off the gulf coast of the United States was under consideration in 1976.

Refining Capacity.—Total world crude oil refining capacity was estimated at 75.2 million bpd by yearend 1976 representing a 3.4 million bpd increase over 1975 levels. About 0.9 million bpd of new capacity is attributed to the United States, almost 0.4 million bpd to the People's Republic of China, about 0.3 million bpd to the U.S.S.R., and over 0.2 million bpd for both France and Italy. The Eastern Hemisphere, with major refining centers in the Common Market, in the U.S.S.R., and in Japan, accounted for 65% of total world refining capacity or 49.2 million bpd. Most Eastern Hemisphere refineries operated well below capacity. In the Common Market, where refining capacity totaled 17.3 million bpd, crude oil and blendstock throughput represented only 60% of capacity. Refining capacity of the U.S.S.R. is estimated at 9.5 million bpd, and capacity utilization is estimated at 90%. Japan, where refining capacity totals 5.5 million bpd, operated at 80% capacity. Refining capacity in the Western Hemisphere totaled 26 million bpd. Nearly 16 million bpd refining capacity is in the United States, over 2 million bpd in Canada, and nearly 1.5 million bpd in Venezuela; refineries operated at 85%, 80%, and 60% capacity, respectively.

Consumption.—World petroleum consumption increased by an estimated 4.9 million bpd, raising total consumption to 57.9 million bpd in 1976. Consumption levels in major industrial areas increased as the various economies adjusted to the petroleum price burden. Western European consumption increased by 127,000 bpd to 12.2 million bpd, and the United States increased by 940,000 bpd to 17.4 million bpd.

Australia.—Restrictions on foreign investments and a price ceiling of less than $3.00 per barrel on Australian crude resulted in a sharp decline in exploratory and development drilling. In 1972, a total of 139 exploratory and development wells were drilled. By 1976 drilling activity was reduced to 19 exploration wells and 14 development wells; consequently, crude reserves had dropped to 1.4 billion barrels, about 50% the 1972 reserve level. The Australian Government has reassessed its program and a more favorable investment climate is expected.

Australian crude production averaged 417,000 bpd, the bulk of which was derived from the Esso-Broken Hill Pty, Ltd. operations in Bass Strait where output from the Kingfish, Halibut, and Barracouta fields totaled an average of 385,000 bpd. Two new fields were under development in this area. The Mackerel field, with crude reserves of 200 million barrels, was scheduled to enter production in 1977; production at full development was estimated at 70,000 bpd. The Tuna field, with crude oil reserves of 40 million barrels and natural gas reserves of 500 billion cubic feet, was scheduled for production in 1978. It was reported that at full development, the field should produce 23,000 bpd.

France.—Domestic production averaged 21,000 bpd accounting for about 1% of France's petroleum consumption requirement.

Offshore exploration in the Mer d' Iroise proved promising, but further activity in this area has been suspended pending a decision by the International Arbitration Tribunal as to the median line between the

French Mer d' Iroise and the British Celtic Sea.

In January 1976 the French Government approved the merger of State-owned Enterprise de Recherches et d'Activités Pétrolières (ERAP) and Société National des Petroles d'Aquitaine. The new company is registered as Société Nationale Elf-Aquitaine (SNEA).

In mid-1976 Port Autonome du Havre opened its superport facilities at Antifer about 15 miles north of Le Havre. Antifer can accomodate tankers of 550,000-dwt capacity and can be made to accomodate tankers of 1,000,000-dwt capacity when the need arises. Tankers calling at Antifer offload petroleum for French consumption or use the facilities to transfer the petroleum to smaller tankers for delivery to other European ports of more limited tanker capacity.

India.—Production from the Bombay High offshore structure averaged 17,000 bpd for calendar year 1976 raising India's crude petroleum production to an average of 177,000 bpd for the year. By yearend, however, output from Bombay High approached 35,000 bpd, by yearend 1977 output should reach 80,000 bpd, and at full development in 1979, the field should average 200,000 bpd. The Bombay High structure contains proved reserves of 1.5 billion barrels or half of India's total proven crude petroleum reserve of 3 billion barrels.

The Indian Oil and Natural Gas Commission (ONGC) has reached agreement on the acquisition of the Caltex Oil Refining Co. and the marketing firm, Caltex (India) Ltd. for $14.6 million. Government policy favors discouraging foreign equity. The Caltex acquisition followed similar actions by ONGC in recent years with holdings of Esso Eastern Inc., Royal Dutch/Shell, and Burmah Oil Co., Ltd.

Indonesia.—Liquidity problems of the State oil and natural gas company, Pertamina, prompted the Government to seek a source for rapid cash receipt. One avenue was the renegotiation of long-standing contracts with foreign oil companies. Generally, the existing production sharing contracts designated 40% of production for investment recovery, 20% for delivery to Pertamina refineries at 20 cents above production cost, and divided the remaining production 65%/35% in favor of Pertamina. Revised contracts were signed in midyear and were retroactive to January 1, 1976. The new contracts essentially directed 89% of foreign company income to Pertamina. The new contract terms increased the Governments income by $640 million in 1976, but at the same time reduced the operators cash flow. As a result, exploration and development activity dropped significantly by yearend. During 1976 there were 142 exploratory well completions, a decline of 22% from 1975. Total footage drilled was 748,235 representing a 31% decline from 1975. In spite of reduced drilling activity, 43 new oil and gas wells were discovered for a success ratio of 1.3. Development drilling footage was reported at 1,549,699, also an appreciable drop from 1975 levels. Reduced exploration and development activity will probably continue in 1977, but a reversal might be anticipated by 1978, as the Indonesia Government announced that contract modifications allowing for exploration incentives would be forthcoming in 1977.

Indonesian crude oil production averaged over 1.5 million bpd, representing a 15% increase over the 1975 level. The adjustment of Indonesian crude prices to more competitive levels contributed signficantly to increased demand and the consequent increased production. Companies from the United States accounted for 85% of total production. Affiliates of Texaco, Inc. and Standard Oil of California alone accounted for 56% of total production.

Productive capacity of Indonesian fields approximated 1.75 million bpd in 1976, but should increase to 1.8 million bpd in 1977 when additional capacity becomes available from Cia. Française des Pétroles and Atlantic Richfield Co. operations in East Kalimantan, from Phillips Petroleum Co. operations in Irian Jaya, from Independent American Petroleum Co. operations in the Java Sea, and from Pertamina and Caltex Pacific Indonesia operations in Sumatra.

Crude petroleum exports were revitalized in 1976 averaging well over 1.2 million bpd. Japanese and U.S. markets absorbed 43% and 41%, respectively, of all Indonesian crude petroleum exports. Eight refineries with a combined capacity of 523,000 bpd are owned and operated by Pertamina, including the 100,000-bpd-capacity Cilacap refinery inaugurated in August 1976. Indonesia's only other refinery is the 4,000-bpd-capacity refinery at Cepu operated by the Oil and Gas Academy (Lemigos). Overall refinery output in 1976 averaged 310,650 bpd. This includes 83,000 bpd processed by two Singapore refineries under special arrangements with Pertamina. Petroleum product exports averaged 100,000 bpd. Product exports were almost entirely residual fuel processed from Minas Sumatran crude for direct-burning power generation in Japan.

Iran.—The petroleum industry is dedicated to sustaining high production levels for as long a period as possible, and to maximizing ultimate recovery by reservoir pressure maintenance. The goals were reinforced in 1976 as the initial phase of the $2.5 billion, 13,000 million-cubic-foot-per-day gas reinjection program was implemented. Four injection wells were drilled in the Haft Kel field where 400 MMcf per day of gas was injected. The gas was transported through a 24-inch pipeline connecting six wells in the Naft Safid field to the Haft Kel field. By yearend gas injection also commenced at Gachsaran and Agha Jari, Dome and associated gas from the Pozanan field was the supply source for gas injection programs in the Gachsaran and Aga Jari fields. A gas injection project was scheduled for the Pars field in 1977, gas was to be delivered by an extension of the Haft Kel 24-inch pipeline.

Crude oil production for 1976 averaged 5.9 million bpd; however, near capacity peak production levels were reached in the fourth quarter when output averaged 6.6 million bpd. Demand for crude registered a sharp rise at yearend as buyers attempted to stockpile as much crude as feasible in view of the announced January 1977 price increase. More than 90% of Iran's output comes from the Khuzestan fields in southwest Iran owned by the National Iranian Oil Co. (NIOC) and operated by the Oil Services Co. (OSCO). Among the larger fields in this area are the Marun field where production averaged 1,340,000 bpd in 1976, the Ahwaz field where production averaged 930,000 bpd, the Agha Jari field where production averaged 850,000 bpd, and the Gachsaran field where production averaged 620,000 bpd. Production from the last two fields reportedly would be appreciably increased in 1977 as a result of the gas injection program.

Of total Iranian crude production, at least 400,000 bpd was derived from offshore wells. NIOC has 50% interest in all offshore oil production. Companies producing in Iranian waters are Lavan Petroleum Co., Iranian Marine International Oil Co. , Iran Pan American Oil Co. and Société Irano-Italienne des Pétroles.

Crude exports averaged 5.2 million bpd in 1976. About 600,000 bpd was refined in Iran for domestic consumption. Iran's petroleum consumption growth rate was anticipated to be about 16% to 18% yearly for the next 5 years. In line with increased domestic consumption, the domestic refining capacity will be raised from 750,000 bpd in 1976 to 980,000 bpd in 1977, and to 1,450,000 bpd in 1981. Additional refinery capacity will emphasize production of middle distillates as this group represents 55% of Iran's consumption pattern.

Construction of the 80,000-bpd-capacity Tabriz refinery continued on schedule and completion was anticipated by April 1977. The refinery will process crude from the Ahwaz field for consumption in northwest Iran. In December 1977 ground breaking ceremonies launched construction of a 200,000-bpd-capacity refinery at Isfahan. The first of two 100,000-bpd-capacity distillation columns and supporting units will be operational in the spring of 1978, and the second will be operational in the fall of the same year. The Abadan refinery was under expansion raising capacity from 450,000 bpd to 600,000 bpd by 1977. A 300,000-bpd refinery is planned for completion by 1981. The location of this refinery has not yet been announced.

Iraq.—Production averaged 2,415,000 bpd for calendar year 1976; however, output in the last quarter surged averaging 3 million bpd in December. The bulk of crude output was derived from the Kirkuk complex followed by production from the Rumaila and Zubair fields. Three new fields, the Buzurgan, the Abu Ghirab, and the Fauqi, were under development in 1976. These fields are located in Southern Iraq near the Iranian border. The Buzurgan and Abu Ghirab fields entered production in October with crude oil averaging 23° API gravity and 3.7% sulfur. At yearend a commercial discovery was announced near Al-Qurnah. The new field, the Majnoon, has an estimated reserve of 2 billion barrels. Production capacity is estimated at 350,000 bpd.

In April, after a sustained dispute over transit fees and over prices on crude delivered to the Syrian Homs refinery, Iraq suspended shipments through pipeline from Northern Iraq across Syria to the Mediterranean terminals of Banias and Tripoli. Crude petroleum output was rerouted through a newly constructed 410-mile pipeline connecting the northern fields with Fao on the Gulf of Basrah. At Fao two submarine pipelines of 48-inch-diameter run a length of 25 miles to four offshore loading berths. Still another outlet for Iraqi crude exports should be available in 1977, when the 610-mile pipeline connecting Iraq fields to the Port of Dortyol, Turkey is operational.

Italy.—More than 50 Italian and foreign companies are exploring for oil and gas in Italy. Onshore concessions are concentrated in Italy near Tuscany, Lazio, and Abruzzi; while the offshore search is centered along the southern Adriatic Sea into the Ionian Sea and in the waters of Sicily and the smaller island groups between Italy and Tunisia. Italian reserves are estimated at 315 million barrels, no significant additions to reserves have been reported in 1976.

Italian refining centers have a rated capacity totaling well over 4 million bpd. Refineries continued to operate well below capacity as crude throughput, virtually all imports, averaged only 2.1 million bpd.

Kuwait.—Kuwait Law 10 of 1976 was ratified in March abolishing retroactively to March 1975 all previous oil concessions and participation agreements between the Government of Kuwait, the Gulf Oil Co., and British Petroleum Corp. (BP) in connection with the Kuwait Oil Co. (KOC) and its operations. The State assumed full control over the Nation's petroleum industry; however, both the Gulf Oil Co. and BP are under fee for technical assistance.

The KOC, now fully State-owned, accounted for all production in Kuwait, which averaged 1,912,569 bpd in 1976. The American Independent Oil Co. (Aminoil) accounted for all Kuwait onshore production in the Neutral Zone. Aminoil produced an average of 80,659 bpd in 1976. The Kuwait share of offshore operations in the Neutral Zone was 152,192 bpd. Offshore operations in the Neutral Zone are conducted by the Arabian Oil Co. (AOC) for both Kuwait and Saudi Arabia. The combined recovery from Kuwait and from that Nation's share of the Neutral Zone production averaged 2,147,000 bpd.

Nearly 1.8 million bpd, or more than 80% of the crude output was exported. The Far Eastern markets accounted for nearly half of the crude oil exports.

Mexico.—The State-owned company Pétroleos Mexicanos, S.A. (Pemex) announced a 6-year petroleum industry development program which would increase production from nearly 1 million bpd to 2.2 million bpd in the 1976-81 period. Pemex investment budget for this time frame provides $8.4 billion for exploration and development, $2.3 billion for refining expansion, $2.6 billion for petrochemical expansion, and $2.2 billion for transportation development.

During the 6-year period, Pemex plans to drill 1,324 exploratory wells and 2,152 development wells. Refinery capacity will be augmented by completing two new refineries with a combined capacity of 270,000 bpd, and by a 200,000-bpd expansion of both the Tula and the Salina Cruz refineries bringing total refinery capacity to 1.67 million bpd by 1981.

Petroleum exports, predominantly crude oil, averaged less than 100,000 bpd in 1976. Petroleum exports are planned at 1.1 million bpd in 1981, with products accounting for nearly two-thirds.

Nigeria.—Investment in exploration and development declined since 1974, when the Government acquired majority ownership in the producing companies. By yearend 1976 onshore rig count had dropped to 15 compared with 23 in operation in 1975.

The largest producer is the Petroleum Development Co., a joint venture between Royal Dutch/Shell and BP in which the Nigerian National Oil Co. (NNOC) recently acquired 55% equity. Shell/BP production averaged 1.23 million bpd from 75 onshore fields. Other major producers were Gulf Oil Co. averaging nearly 300,000 bpd, Mobil Oil Co. averaging 230,000 bpd, and ENI-Phillips averaging 186,000 bpd. The NNOC recently acquired 55% equity in the preceding companies as well.

Norway.—Crude oil production from the Ekofisk complex in the Norwegian Continental Shelf averaged 279,000 bpd in 1976. A deep trench along the coast of Norway renders a pipeline unfeasible; therefore, Norwegian offshore production was delivered to Teeside, England, for export or refining through a 34-inch-diameter, 200-mile pipeline of 1-million-bpd capacity. Terminal facilities at Teeside include stabilization units, tanker loading berths, and storage capacity for 7.5 million barrels.

In mid-1976, the Norwegian Parliament approved the development of the Statfjord field and requested that a 2-year testing program be launched in an effort to construct a pipeline across the Norwegian trench to connect this field with the Norwegian coast. The Statfjord field, discovered in 1974 by Mobil Oil Co., has an estimated recoverable reserve of 3.9 billion barrels of oil and 100 billion cubic meters of associated gas. Initial production from this field should be realized in 1979 at 60,000 bpd, and production at full development is anticipated at 900,000 bpd.

During 1976, two major discoveries on the Norwegian Continental Shelf were announced; Mobil Oil Co. announced a discovery in bloc 33/9 near Statfjord and Continental Oil Co. announced a discovery in bloc 7/12 near Cod.

Statoil, the Norwegian State oil company is at least a 50% partner in all petroleum exploration and development activity. On January 1, 1976, a State petroleum distribution company was formed under Norsk Olje (NOROL), following the Norwegian Government purchase of Norsk Braendselolje, Norske OK, and Norsk Hydro A/S.

Saudi Arabia.—The long pending takeover of the sole producing company in Saudi Arabia, the Arabian American Oil Co. (Aramco), had not materialized by yearend. Among the points still under negotiation were the details of the management contract.

Aramco reported the discovery of three new fields in 1976, located at Hasbah, Sharar, and Suban. Aramco's net addition to reserves at yearend were 2.3 billion barrels proved and 1.7 billion barrels probable. Aramco reported proved reserves at yearend at 110.2 billion barrels, and probable reserves at 177.5 billion barrels. These figures are for Saudi Arabian reserves and do not include about 3 billion barrels of the Saudi Arabian share from the Neutral Zone. The Government of Saudi Arabia has issued a less conservative estimate of proved reserves at 151.4 billion barrels.

Crude oil production from Saudi Arabia and from that Nation's share of Neutral Zone production averaged nearly 8.6 million bpd in 1976, a 21% increase over the 1975 average. Peak production level was achieved at 9.4 million bpd for the month of November as buyers accelerated crude oil purchases before the January price hike.

More than half of Saudi Arabia's 1976 production was derived from the giant Ghawar field which averaged 5.2 million bpd. Pressure maintenance techniques applied at Ghawar are the injection of saline aquifer water in the northern, eastern, and western perimeters, and the reinjection of gas in the northern dome. A massive seawater supply project is under construction to reduce dependence on aquifer water for pressure maintenance. The seawater will be collected just south of Dhahran and transported via a 65-mile long pipeline. The initial phase of the seawater pressure maintenance program will be in operation by 1978, when 4.2 million bpd of treated seawater will be available for injection. Future expansion to a 12-million-bpd capacity is programed.

At the December OPEC ministerial meeting, Saudi Arabia together with Abu Dhabi rejected the 10% price increase adopted by 11 other members of OPEC and launched a two-tier price system by adopting a 5% price increase effective January 1, 1977. At the same time Saudi Arabia announced its intention to increase production capacity from the 1976 level of nearly 12 million bpd to 16 million bpd by 1982.

U.S.S.R.—Production of crude oil and field condensate averaged 10.4 million bpd, maintaining the Nation's lead in world production of liquid hydrocarbons. The Urals-Volga region, which includes the major producing areas of Tataria, Bashkiriya, and Kuibyshev, accounted for nearly 4.5 million bpd. Production from Western Siberia followed with a reported output of 3.6 million bpd. The largest field in Western Siberia is Samotlor where output from more than 1,000 producing wells totaled an average of 2.2 million bpd in 1976. Soviet sources report the anticipated peak production of Samotlor at 2.7 million bpd in 1977 revising various earlier projections, while production at Samotlor rises to peak levels, development activity in Western Siberia continues. The following fields entered production in 1976: Kholmogorskoye, Severo-Vareganskoye, Lokoskovskoye, Yuzhno Balyskoye, Severo Pokurskoye, and Yuzhno Surgutskoye. Soviet production goals for Western Siberian fields are set at 6 million bpd by 1980, or nearly half of total Soviet projected output for that year.

Offshore production in the Soviet Union totaled 220,000 bpd of crude oil and field condensate, falling well below the 1976 planned goal. All Soviet offshore production is derived from Caspian Sea deposits, the largest of which is the Baku Archipelago, which accounted for 100,000 bpd or nearly half of the offshore output, followed by the Neftianye Kamni field, which yielded about 70,000 bpd.

Offshore drilling activity has been hampered by the lack of mobile drilling units often resulting in the time-consuming and costly construction of fixed platforms for wildcat drilling. The Soviet Union's mobile offshore drilling capability is limited to four jack-up rigs. The Apsheron rig is only capable of drilling in shallow waters not exceeding 50-foot depths with a total drilling depth capability of 5,900 feet. The Azerbaijan rig can operate in water depths up to 66 feet with total drilling depth at

10,000 feet. Recent additions to the Soviet mobile rig fleet are the Netherlands-built Khozar jack-up rig and the Soviet-built Baku jack-up rig; both rigs are capable of operating in 200 feet of water with a maximum drilling depth of 20,000 feet.[10] During the 1976-80 5-year plan, the Soviet Union intends to increase its mobile rig fleet to 12. The rigs will be employed on the Western and Eastern shelves of the Caspian Sea.

Offshore production goals for 1980 have been revised downward from 360,000 bpd to 275,000 bpd. During 1976, new discoveries were reported on the East Bank of the Caspian Sea near the Cheleken Peninsula, the Magyshlak Peninsula, and the Buzochi Peninsula. The development of these fields, as well as several shut-in fields, and the construction of adequate pipeline facilities have been incorporated in the Soviet Union's long-range plans which anticipate Caspian Sea production at 440,000 bpd in 1985.

Soviet sources report refining capacity at 9.5 million bpd. Total exports of crude petroleum and refined products averaged 3 million bpd. More than half of the petroleum exports or 1.7 million bpd were delivered to other centrally controlled economies, while shipments to Western Europe averaged nearly 1 million bpd.

United Kingdom.—Five new fields came onstream in the United Kingdom's section of the North Sea during 1976. The Auk field, owned by Shell U.K., Ltd. and Esso Petroleum Co., Ltd., entered production in February. Production at full development is estimated at 50,000 bpd. The Beryl field, owned by Mobil Producing North Sea, Ltd; Amerada Exploration Ltd.; Texas Eastern (UK), Ltd.; and the British Gas Corp., came onstream in June. Production at full development is estimated at 100,000 bpd by 1978. The Montrose field, owned by the British Gas Corp.; Amoco U.K. Petroleum, Ltd.; Amerada Exploration, Ltd.; and Texas Eastern U.K., Ltd., also came onstream in June. Production at full development is estimated at 60,000 bpd by 1978. The Brent field, owned by Shell UK, Ltd. and Esso Petroleum Co., Ltd., entered production in November. Production at full development will be 450,000 bpd. The Piper field, owned by Occidental Petroleum (UK), Ltd.; Getty Oil International (England), Ltd.; Allied Chemical (Great Britian), Ltd.; and Thomson North Sea, Ltd., came onstream in December. Production from the Piper field is anticipated at 250,000 bpd by yearend 1977. Combined U.K. production from the North Sea averaged 230,000 bpd in 1976. This includes output from the five fields which entered production in 1976 as well as output from the Argyll and Forties fields which have been onstream since 1975. By yearend 1976, daily production from these seven fields in the North Sea was averaging 500,000 barrels. The rate of production should continue to climb through 1977 reaching a daily average well in excess of 800,000 barrels, or about half of the U.K. consumption requirement. Two additional fields, Thistle and the Claymore, were scheduled to come onstream late in 1977.

Other significant developments in 1976 include the conclusion of agreements on State participation which in effect gave the British National Oil Co. the right to buy nearly 1.3 million bpd by 1980 at the prevailing price, and the discovery of 12 new oil and 2 gasfields bringing total discoveries to 73 since offshore exploration began in 1964.

Venezuela.—Nationalization of the petroleum industry was in effect as of January 1, 1976, and compensation to foreign companies and subsidiaries was $1.1 billion. The transfer involved 5.4 million acres of concession holdings over 18 billion barrels of proved reserves well over 7,000 producing wells, 1.5 million bpd in refining capacity, over 6,000 miles of pipelines, as well as tankers, terminals, and other facilities.

Petróleos de Venezuela (Petroven) is the State holding company for 14 new operating companies. Production averaged 2.2 million bpd, and oil sales were reported at $8.84 billion. The Venezuelan Treasury's share of net sales totaled $6.77 billion. Capital investment in the oil industry was $375 million in 1976 and scheduled to increase to $700 million in 1977.

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[10]Oil and Gas Journal. Russia to Triple Mobile Rigs by 1980. V. 75, No. 11, Mar. 14, 1977, p.29.

TECHNOLOGY

During 1976, technological development in production, refining, transportation, storage, and marketing have contributed to the efficient use of energy. The decrease in the time used in drilling the well helped to advance production. Refineries are using new procedures and processes to refine less desirable oil into desired products; some products in demand, like gasoline, are being extended by adding methanol. Heat energy is being contained as tanks, which store petroleum, are being insulated to prevent heat loss. A fuel oil additive to improve combustion and reduce pollution is being marketed. The private individual can buy an oil filter with additives for the oil to increase the effectiveness of the oil.

Domestic production is dependent on the addition of new producing wells. The new technological developments allow these wells to be drilled fast and in deep water in the Outer Continental Shelf.

Computer assisted drilling technology is being developed by Baroid Research to provide the drilling rig operator with computerized well control. Applied drilling technology (ADT) service by Baroid is designed to help operators drill wells with optimum efficiency and minimum hazards, through accurate formation pressure control. The data recorded are utilized for normalized drilling rates, total mud and mud weight available, continuous gas in mud, pump pressure, casing pressure, mud viscosity, and normalized shale density for variations in mineral composition. With these observations mud properties can be established to control formation pressure during trips, prevent gas kicks and their control, while not exceeding the fracture gradient causing loss circulation problems. Functions monitored by nondigital instrumentation and manually monitored include formation density, penetration rate, formation drill ability, cost per foot, lagged mud temperature and resistivity, and formation pore pressure.

Computerized drilling permits optimization of the drilling process through rapid data acquisition and analysis. Drilling costs are minimized by optimum bit weight and rotary speed for best bearing load and tooth wear. Hydraulics are continuously optimized by computer to determine slip velocities, critical velocities, equivalent circulating density, pressure drops, and hydraulic horsepower for best hole cleanout and mud circulation.[11]

The U.S. Energy Research and Development Administration (ERDA)[12] and private companies tested downhole engines (electrical motors or turbines) to drive the drill bit. The method tested was an electrical motor for offshore directional drilling. The downhole and surface electronic package was built to combine directional control with the ability to sense downhole parameters in realtime so drilling procedures change as downhole conditions change. These attempts to improve the speed and accuracy of drilling by putting the drill-turning motor near the drill bit instead of imparting motion to the entire string of drill pipe is done as an economic basis.[13]

Stratapax is a polycrystalline diamond blank for drill bits, which is supplied by General Electric Co. to drill bit fabricators. Blanks made of Stratapax have proved higher impact and abrasion resistant for longer bit life. The high abrasion resistance is due to the polycrystalline structure which has no cleavage planes but many tiny, randomly oriented crystals bonded to each other. The drill bits made with Stratapax blanks can double the penetration rates of conventional bits in soft and medium-hard stratas, but drilling problems in hard or abrasive formations have not been solved.[14]

Exxon Corp. installed a production and drilling platform in the Hondo field. The platform, set in 850 feet of water off California, has a total height of 945 feet, is in the Santa Yves unit with plans to drill 28 development wells to a depth of 11,000 feet. Estimated production in 1978 from this field is 60,000 barrels of oil daily and 77 million cubic feet of gas daily from three platforms.

Numerous technological advancements were realized in refining during 1976. Gulf Oil Corp. and Mobil Oil Corp. developed technology which they claim would permit refiners to produce larger amounts of gasoline and middle distillates from crude oil by means of hydrotreating and fluid catalytic cracking.[15]

Chevron Research Co. developed a process for catalytically reforming naphthas into

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[11]NL Industries, Inc. Applied Drilling Technology Unite; Baroid Petroleum Services. February 1976, p.13.

[12]ERDA was transferred to the Department of Energy on Oct. 1, 1977.

[13]Oil Daily. Downhole Motors. No. 6,308, Jan. 7, 1977, p. 8.

[14]——. G.E. Getting Into Oil Patch Business. No. 6,284, Jan. 2, 1976, pp. 1-2.

[15]——. Use of Processing Advances to Get More Distillate Could Cut Imports. No. 6,197, July 29, 1977, pp. 1-2.

motor gasoline blending stocks and aromatic chemicals. A bimetallic catalyst utilizes platinum and rhenium on alumina and results in lower fouling rates and lower catalyst costs.

A new process developed by Mobil Oil Corp. reportedly yields 75% to 80% high-quality 90-100 RON gasoline in a single pass of methanol through a pilot reactor using a zeolite catalyst. The company states that the yield can be boosted to 90% of the input by using a secondary process. Mobil researchers estimated the production cost of gasoline from coal-derived methanol is 5 cents per gallon.[16]

Advanced air emissions and water control systems, installed at the Amoco Oil Co.'s petroleum refinery at Texas City, Tex., resulted in a reduction in pollution from the plant. Electrostatic precipitators on the catalytic cracking units contributed to a 92% drop in particulate emissions from the refinery over a 2-year period. The plant's storm and waste water processing system likewise resulted in a significant decrease in pollutants discharged from the refinery.[17]

In France, a new technique called hydropyrolysis was developed for cracking gas oil and naphtha feedstocks at high temperatures and pressures to produce large yields of ethylene.[18]

Several new catalysts were developed for use in petroleum refining during the year. Nitto Chemical Industry Co., Ltd. of Japan and Standard Oil Co. of Ohio (Sohio) announced a new catalyst for Sohio's acrylonitrile process.

In West Germany, an automobile fuel of 85% gasoline and 15% methanol has been tested.

Energy efficiency is being extended to the tank farms at refineries by application of insulation to petroleum storage tanks. Several domestic companies gained experience during the year in applying glass, polyurethane, and other foam insulation to petroleum storage tanks. It is reported that a significant energy savings was realized on heated tanks at which foam insulation had been installed.[19]

Two new products now available to the public and industry are a time release additive system to fortify an automobile's engine lubricating oil, and a fuel oil additive to improve combustion and reduce visible smoke pollution.

Monroe Auto Equipment Co. developed a time-release additive system packaged with an oil filter that would extend the life of automobile engine lubricating oils. While Monroe's new filter cleans the oil, antioxidants, antiwear agents, and viscosity improvers are released in the oil.[20]

Drew Chemical Corp. began marketing a new blend of combustion catalysts, solvents, dispersants, and water-emulsifying agents to be added to fuel oil in industrial boilers. Use of the product reportedly improves combustion resulting in reduced fuel consumption, reduced corrosion and slag deposits in boilers, and reduces noxious and visible smoke pollution.[21]

NATIVE ASPHALT

Bituminous Limestone, Sandstone, and Gilsonite.— Natural rock asphalt and limestone rock asphalt were produced in Alabama, Missouri, and Texas, and were used for roadbuilding material. Gilsonite was produced in Utah. The total production of native asphalts and related bitumens in 1976 was 2,011,500 short tons with a value of $17,647,000.

[16]Oil and Gas Journal. Methanol-to-Gasoline Process Advances. V. 74, No. 10, Mar. 8, 1976, p. 36.
[17]Oil Daily. Amoco Adds Properietary Process Design to Best Technology Currently Available, Gets Most Sophisticated Water Control. No. 6,060, Jan. 14, 1976, pp. 5-6.
[18]Chemical and Engineering News. Naphtha Cracking: New High-Yield Process. V. 54, No. 45, Nov. 1, 1976, p. 18.
[19]Oil Daily. Foam Tank Insulation Subject of Many Meetings. No. 6,141, May 11, 1976, Supplement p. 12.
[20]———. Dissolving Additive Package New Oil Filter's Unique Feature. No. 6,095, Mar. 5, 1976, p.3.
[21]Energy User News. Drew: Oil Additive Cuts Fuel Use 5%. V. 1, No. 12, Dec. 20, 1976, p. 9.

Table 2.—Supply, demand, and stocks of all oils in the United States

(Thousand barrels)

Item	1972	1973	1974	1975	1976[p]
Domestic production:					
Crude oil	3,293,399	3,206,012	3,056,936	2,922,654	2,845,955
Lease condensate	161,969	154,891	145,649	134,125	130,225
Natural gas plant liquids	638,216	634,423	616,098	595,958	587,045
Imports:[1]					
Crude oil	811,135	1,183,996	1,269,155	1,498,181	1,935,142
Unfinished oils	45,705	50,161	44,228	12,985	11,735
Plant condensate	31,428	39,344	32,364	26,972	24,408
Refined products	847,046	1,009,992	885,200	672,197	698,644
Other hydrocarbons and hydrogen refinery input	10,118	10,716	13,057	13,779	13,949
Total new supply	5,839,016	6,289,535	6,062,687	5,876,851	6,247,103
Crude oil unaccounted for[2]	+10,201	+918	-9,084	+6,048	+28,079
Processing gain	142,161	165,488	175,255	167,782	174,675
Total supply	5,991,378	6,455,941	6,228,858	6,050,681	6,449,857
Change in stocks, all oil	-84,968	+49,328	+65,339	+11,839	-21,145
Total disposition of primary supply	6,076,346	6,406,613	6,163,519	6,038,842	6,471,002
Exports:[3]					
Crude oil	187	697	1,074	2,146	2,941
Refined products	81,202	83,716	79,417	74,282	78,658
Crude losses	4,641	4,897	4,789	4,899	5,265
Domestic demand for products:					
Gasoline:					
Motor gasoline	2,333,778	2,436,156	2,386,177	2,436,229	2,553,834
Aviation gasoline	16,925	16,531	16,215	14,067	13,362
Total gasoline	2,350,703	2,452,687	2,402,392	2,450,296	2,567,196
Jet fuel:					
Naphtha-type	88,495	79,220	81,171	76,543	72,713
Kerosine-type	293,995	307,407	281,429	288,747	288,645
Total jet fuel	382,490	386,627	362,600	365,290	361,358
Ethane (including ethylene)	106,201	119,443	124,582	124,548	132,707
Liquefied gases	413,649	409,318	388,503	361,897	381,263
Kerosine	85,852	78,915	64,352	57,990	61,920
Distillate fuel oil	1,066,110	1,128,714	1,075,916	1,040,571	1,145,645
Residual fuel oil	925,647	1,030,177	963,216	898,572	1,019,588
Petrochemical feedstocks[4]	123,697	129,929	132,468	116,773	152,856
Special naphthas	31,866	32,230	31,976	27,490	30,109
Lubricants	52,813	59,171	56,670	50,169	55,732
Wax	5,409	6,941	6,801	6,076	7,210
Coke	88,276	95,156	87,056	90,048	89,091
Asphalt	163,788	182,602	168,733	147,384	146,763
Road oil	7,538	7,832	6,881	5,453	3,647
Still gas for fuel	170,993	176,758	175,724	175,351	180,666
Miscellaneous products	15,284	18,934	24,263	32,674	47,464
Plant condensate	--	1,869	6,106	6,933	923
Total domestic demand	5,990,316	6,317,303	6,078,239	5,957,515	6,384,138
Stocks of all oils:					
Crude oil and lease condensate	246,395	242,478	265,020	271,354	285,471
Unfinished oils	94,761	99,154	106,031	106,352	110,488
Natural gasoline[5]	4,802	6,160	6,480	6,217	6,649
Refined products	611,748	658,840	695,045	747,867	707,723
Plant condensate	1,273	1,675	1,070	1,165	1,479
Total	958,979	1,008,307	1,073,646	1,132,955	1,111,810

[p]Preliminary (except for crude oil and lease condensate production).
[1]U. S. Department of the Interior data for crude oil, unfinished oils, and plant condensate; U. S. Department of Commerce and Federal Energy Administration data for all other imports. Imports of crude oil include some Athabasca hydrocarbons.
[2]Represents the difference between total disposition and the indicated demand for crude petroleum.
[3]U. S. Department of Commerce data.
[4]Produced at petroleum refineries. Demand for ethane and liquefied gases used for petrochemical feedstocks are excluded. Demand data for these products for petrochemical feedstocks used are included under the items "Ethane" and "Liquefied Gases."
[5]Includes isopentane.

Table 3.—Supply and demand of all oils in the United States, by month

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1975													
New supply:													
Domestic production:													
Crude oil	250,526	229,936	251,667	242,363	248,419	241,738	247,193	244,241	237,821	246,715	237,822	244,213	2,922,654
Lease condensate	11,578	10,616	11,630	11,335	11,323	10,886	11,215	11,471	10,568	11,342	10,514	11,647	134,125
Natural gas plant liquids	50,515	46,086	51,396	49,056	49,818	49,390	50,260	51,143	47,302	50,922	49,048	51,022	595,958
Imports:[1]													
Crude oil	124,901	107,194	113,345	101,338	108,072	117,142	129,966	142,016	140,675	136,068	138,703	138,761	1,498,181
Unfinished oils	921	1,323	1,330	817	841	1,291	1,354	1,066	816	1,212	836	1,178	12,985
Plant condensate	2,430	1,836	2,544	2,231	1,828	2,212	2,311	2,514	2,646	1,842	1,971	2,607	26,972
Refined products	84,428	62,578	60,411	46,823	50,894	41,544	51,097	49,650	59,991	57,082	51,060	56,639	672,197
Other hydrocarbons and hydrogen refinery input	946	850	775	1,110	1,128	1,214	1,498	1,326	1,116	1,303	1,349	1,164	13,779
Total new supply	526,245	460,419	493,098	455,073	472,323	465,417	494,894	503,427	500,935	506,486	491,303	507,231	5,876,851
Crude oil unaccounted for[2]	+1,301	+55	-3,214	+1,840	+3,633	-1,196	+1,063	+44	+3,259	+280	-3,918	+2,901	+6,048
Processing gain	16,084	12,272	13,043	11,434	12,768	12,970	13,365	13,812	15,841	15,905	14,839	15,449	167,782
Total supply	543,630	472,746	502,927	468,347	488,724	477,191	509,322	517,283	520,035	522,671	502,224	525,581	6,050,681
Change in stocks, all oils[3]	-21,972	-12,930	-9,854	-19,199	+12,235	+1,754	+15,200	+20,565	+40,423	+8,787	+23,520	-46,690	+11,839
Total disposition of primary supply	565,602	485,676	512,781	487,546	476,489	475,437	494,122	496,718	479,612	513,884	478,704	572,271	6,038,842
Exports:[4]													
Crude oil	836	942	349	19	--	--	--	--	--	--	--	--	2,146
Refined products	6,234	6,002	6,257	5,694	6,275	6,733	5,756	6,289	6,159	5,796	4,977	8,110	74,282
Crude losses	411	370	399	384	401	403	430	434	418	413	410	426	4,899
Domestic demand for products:													
Gasoline:													
Motor gasoline	192,382	170,691	196,097	201,542	213,010	212,285	218,258	217,257	201,861	210,107	191,690	211,049	2,436,229
Aviation gasoline	978	1,046	1,037	1,176	1,116	1,213	1,443	1,350	1,365	1,349	1,071	923	14,067
Total gasoline	193,360	171,737	197,134	202,718	214,126	213,498	219,701	218,607	203,226	211,456	192,761	211,972	2,450,296

Jet fuel:													
Naphtha-type	5,282	5,768	6,364	5,758	6,678	5,782	5,985	6,597	7,012	6,833	7,097	7,387	76,543
Kerosine-type	26,994	24,320	24,080	24,424	23,623	23,899	23,586	25,843	24,179	24,066	22,875	20,858	288,747
Total jet fuel	32,276	30,088	30,444	30,182	30,301	29,681	29,571	32,440	31,191	30,899	29,972	28,245	365,290
Ethane (including ethylene)	10,909	9,483	10,305	9,957	10,056	9,137	10,315	10,599	10,604	11,413	10,630	11,140	124,548
Liquefied gases:													
LRG for fuel use[5]	7,747	6,151	6,282	6,157	5,686	5,509	6,890	6,710	6,811	6,680	6,134	7,402	78,159
LRG for chemical use[5]	1,993	1,857	2,176	1,785	2,042	2,814	2,818	2,888	2,811	2,470	2,515	2,561	28,730
LPG for fuel and chemical use[6]	31,864	24,441	24,274	18,928	12,941	12,262	16,495	16,996	17,116	23,295	23,220	33,176	255,008
Total liquefied gases	41,604	32,449	32,732	26,870	20,669	205,585	26,203	26,594	26,738	32,445	31,869	43,139	361,897
Kerosine	6,814	7,078	5,182	4,384	3,017	3,961	3,022	3,317	3,750	4,528	4,403	8,534	57,990
Distillate fuel oil	122,848	106,490	102,043	92,812	73,852	68,023	65,390	67,365	64,895	82,990	76,308	117,555	1,040,571
Residual fuel oil	100,845	79,762	82,727	66,974	64,690	65,310	68,814	66,860	69,846	70,320	72,162	90,262	898,572
Petrochemical feedstocks:													
Still gas	1,313	1,145	1,077	1,155	1,070	1,298	1,379	1,430	1,309	1,482	1,704	1,361	15,723
Naphtha-400°	4,613	3,517	4,214	3,586	3,961	4,272	4,518	4,557	5,041	5,053	5,164	5,016	53,512
Other	5,033	2,935	3,732	2,517	3,122	3,895	4,283	4,507	3,975	4,592	4,212	4,735	47,538
Total petrochemical feedstocks	10,959	7,597	9,023	7,258	8,153	9,465	10,180	10,494	10,325	11,127	11,080	11,112	116,773
Special naphthas	2,141	2,099	1,786	2,296	2,361	2,103	2,808	2,157	2,335	2,419	2,426	2,559	27,490
Lubricants	4,533	3,187	3,250	4,309	4,210	4,473	4,243	4,609	4,443	4,858	3,704	4,350	50,169
Wax	590	404	348	498	392	421	524	529	596	695	568	511	6,076
Coke	7,645	6,958	6,900	7,210	6,723	6,963	8,409	7,810	7,532	8,519	7,531	7,848	90,048
Asphalt	5,596	5,267	6,100	9,141	12,730	17,127	18,274	19,096	18,924	17,734	11,479	5,916	147,384
Road oil	236	50	98	190	414	694	1,640	664	416	312	476	263	5,453
Still gas	14,798	12,919	14,312	13,674	14,822	14,536	16,264	15,743	14,871	14,273	13,860	15,279	175,351
Miscellaneous products	2,526	2,397	2,893	2,551	2,956	2,115	2,186	2,252	2,348	3,237	3,270	3,943	32,674
Plant condensate	441	397	499	425	341	209	392	859	995	450	818	1,107	6,933
Total domestic demand	558,121	478,362	505,776	481,449	469,813	468,301	487,936	489,995	473,035	507,675	473,317	563,735	5,957,515

See footnotes at end of table.

Table 3.—Supply and demand of all oils in the United States, by month —Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1975 —Continued													
Stocks all oils:													
Crude oil and lease condensate	270,462	276,755	279,989	281,908	280,961	276,132	264,157	256,616	259,446	269,584	270,950	271,354	271,354
Unfinished oils	97,488	99,182	103,345	107,071	113,922	111,605	108,580	110,759	107,374	106,327	108,767	106,352	106,352
Natural gasoline[7]	6,684	6,330	5,996	5,938	6,105	6,996	6,577	6,373	6,247	6,059	5,954	6,217	6,217
Plant condensate	1,115	1,271	1,115	1,057	1,159	1,337	1,117	978	979	1,054	892	1,165	1,165
Refined products	723,395	702,676	685,915	661,187	667,249	675,080	705,919	732,189	773,292	773,101	793,082	747,867	747,867
Total	1,099,144	1,086,214	1,076,360	1,057,161	1,069,396	1,071,150	1,086,350	1,106,915	1,147,338	1,156,125	1,179,645	1,132,955	1,132,955
1976[p]													
New supply:													
Domestic production:													
Crude oil	243,823	228,461	243,852	231,621	240,641	232,271	241,120	240,813	234,225	239,018	231,487	238,623	2,845,955
Lease condensate	11,362	10,244	11,346	10,689	11,219	10,562	10,822	10,616	10,264	10,944	10,901	11,256	130,225
Natural gas plant liquids	49,137	47,573	50,072	48,481	49,218	48,166	49,340	49,482	48,071	49,621	48,618	49,266	587,045
Imports:[1]													
Crude oil	142,427	122,030	146,879	143,687	144,748	168,641	179,540	172,221	176,237	176,679	178,367	183,686	1,935,142
Unfinished oils	1,586	1,654	878	1,490	1,284	452	728	475	901	422	782	1,083	11,735
Plant condensate	2,616	3,686	2,130	2,579	1,703	1,464	1,820	1,612	1,354	953	2,015	2,476	24,408
Refined products	59,997	64,938	57,313	50,104	48,279	53,813	62,513	54,531	58,890	54,684	60,642	72,940	698,644
Other hydrocarbons and hydrogen refinery input	1,113	1,188	1,044	1,138	1,156	1,240	1,358	1,027	1,025	1,077	1,090	1,493	13,949
Total new supply	512,061	479,774	513,514	489,789	498,248	516,609	547,241	530,777	530,967	533,398	533,902	560,823	6,247,103
Crude oil unaccounted for[2]	+10,716	+508	+3,837	+300	+2,252	+1,238	+1,347	+2,925	-1,137	+1,184	+5,395	-486	+28,079
Processing gain	14,694	14,168	15,331	13,674	16,977	14,373	15,250	12,788	15,081	12,911	13,961	15,467	174,675
Total supply	537,471	494,450	532,682	503,763	517,477	532,220	563,838	546,490	544,911	547,493	553,258	575,804	6,449,857
Change in stocks, all oils[3]	-44,335	-18,384	-9,747	-3,454	+16,187	+20,328	+40,844	+23,316	+33,830	+12,315	-23,035	-69,010	-21,145
Total disposition of primary supply	581,806	512,834	542,429	507,217	501,290	511,892	522,994	523,174	511,081	535,178	576,293	644,814	6,471,002

Exports:[4]													
Crude oil	--	--	45	--	1	--	--	380	--	563	900	1,052	2,941
Refined products	4,829	6,997	5,680	6,660	5,561	6,383	7,517	6,440	5,877	5,568	9,534	7,612	78,658
Crude losses	419	402	429	411	430	443	460	460	441	443	453	474	5,265
Domestic demand for products:													
Gasoline:													
Motor gasoline	198,347	181,641	213,605	214,782	212,442	224,458	226,772	222,214	212,355	214,799	211,147	221,272	2,553,834
Aviation gasoline	863	837	1,051	1,110	1,088	1,499	1,216	1,471	1,152	1,135	1,025	915	13,362
Total gasoline	199,210	182,478	214,656	215,892	213,530	225,957	227,988	223,685	213,507	215,934	212,172	222,187	2,567,196
Jet fuel:													
Naphtha type	4,405	5,456	5,910	6,181	6,659	5,860	6,616	5,863	7,283	5,501	6,332	6,647	72,713
Kerosine type	24,974	22,536	24,004	24,110	23,107	23,291	27,447	24,063	24,151	22,742	23,020	25,200	288,645
Total jet fuel	29,379	27,992	29,914	30,291	29,766	29,151	34,063	29,926	31,434	28,243	29,352	31,847	361,358
Ethane (including ethylene)	10,803	10,022	11,647	10,671	11,220	10,537	10,641	11,073	11,355	11,746	11,304	11,688	132,707
Liquefied gases:													
LRG[5] for fuel use	7,751	6,624	7,337	6,716	7,054	7,388	6,983	6,774	6,582	7,151	7,316	7,719	85,395
LRG[5] for chemical use	2,484	2,628	3,172	2,985	3,344	2,924	2,978	3,082	2,843	2,278	2,870	3,132	34,720
LPG[6] for fuel and chemical use	36,472	24,739	18,228	15,658	13,667	12,453	13,597	16,675	16,495	25,242	30,911	37,011	261,148
Total liquefied gases	46,707	33,991	28,737	25,359	24,065	22,765	23,558	26,531	25,920	34,671	41,097	47,862	381,263
Kerosine	9,239	6,317	4,920	4,169	2,419	3,618	3,085	2,922	4,486	4,825	6,474	9,446	61,920
Distillate fuel oil	133,233	106,918	103,428	83,629	78,096	73,088	69,909	69,355	78,537	93,885	111,415	144,152	1,145,645
Residual fuel oil	95,144	87,190	86,157	74,868	75,623	75,597	79,205	83,014	75,510	77,851	97,593	111,836	1,019,588
Petrochemical feedstocks:[7]													
Still gas	1,598	1,406	1,465	1,253	1,615	1,550	1,456	1,076	1,070	1,224	1,396	2,339	17,448
Naphtha-400°	5,818	5,742	6,757	6,417	6,618	6,537	6,755	6,558	6,143	6,974	3,933	5,045	73,297
Other	5,610	5,317	5,094	4,756	4,524	4,270	5,483	5,469	4,408	4,811	5,911	6,458	62,111
Total petrochemical feedstocks	13,026	12,465	13,316	12,426	12,757	12,357	13,694	13,103	11,621	13,009	11,240	13,842	152,856

See footnotes at end of table.

Table 3.—Supply and demand of all oils in the United States, by month —Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1976[p] —Continued													
Domestic demand for products: —Continued													
Special naphthas	2,209	2,411	2,600	2,582	2,637	2,878	2,675	1,952	2,724	2,603	2,428	2,410	30,109
Lubricants	3,799	4,069	5,311	4,738	4,523	4,999	5,139	4,504	4,888	4,591	4,530	4,641	55,732
Wax	615	546	615	576	626	588	623	608	653	588	581	591	7,210
Coke	8,245	7,037	7,811	7,331	7,586	7,134	6,527	8,988	7,655	7,116	6,350	7,311	89,091
Asphalt	5,084	4,985	7,924	9,713	13,940	16,996	17,911	20,042	17,720	15,155	11,163	6,130	146,763
Road oil	50	65	47	86	358	365	620	717	388	423	252	276	3,647
Still gas	14,770	14,336	14,723	14,397	14,846	15,815	16,296	16,192	14,939	14,180	14,884	15,288	180,666
Miscellaneous products	4,122	4,613	4,469	3,418	3,306	3,221	3,083	3,282	3,426	3,784	4,571	6,169	47,464
Plant condensate	923	--	--	--	--	--	--	--	--	--	--	--	923
Total domestic demand	576,558	505,435	536,275	500,146	495,298	505,066	515,017	515,894	504,763	528,604	565,406	635,676	6,384,138
Stocks all oils:													
Crude oil and lease condensate	289,296	277,414	283,112	286,628	283,982	281,715	282,599	277,272	284,357	297,683	298,836	285,471	285,471
Unfinished oils	106,164	105,708	110,020	111,447	110,431	111,150	112,739	107,580	109,737	109,661	111,445	110,488	110,488
Natural gasoline[8]	6,608	6,496	7,302	7,054	7,329	7,462	7,115	7,505	7,591	7,307	7,665	6,649	6,649
Plant condensate	960	1,255	1,568	1,969	1,688	1,366	1,413	1,495	1,560	1,353	1,423	1,479	1,479
Refined products	685,592	679,363	658,487	649,937	669,792	691,857	730,528	763,858	788,295	787,851	761,451	707,723	707,723
Total	1,088,620	1,070,236	1,060,489	1,057,035	1,073,222	1,093,550	1,134,394	1,157,710	1,191,540	1,203,855	1,180,820	1,111,810	1,111,810

[p]Preliminary.
[1]U.S. Department of the Interior data for crude oil, unfinished oils, and plant condensate; U.S. Department of Commmerce and Federal Energy Administration data for all other imports. Imports of crude oil include some Athabasca hydrocarbons.
[2]Represents the difference between total disposition and the indicated demand for crude petroleum.
[3]Minus sign represents withdrawal from stock, which is added to total disposition; plus sign represents stocks increase, which is subtracted from total disposition.
[4]U.S. Department of Commerce data.
[5]Liquefied refinery gases.
[6]Liquefied petroleum gas.
[7]Produced at petroleum refineries. Demand for ethane and liquefied gases used for petrochemical feedstocks are excluded. Demand data for these products for petrochemical feedstocks used are included under items"Ethane" and "Liquefied gases."
[8]Includes isopentane.

Table 4.—Supply, demand, and stocks of all oils in 1976, by PAD district

(Thousand barrels)

	PAD District						Total United States
	I	II	III	IV	Total I-IV	V	
Domestic production:							
Crude oil and lease condensate	50,858	327,953	1,967,029	240,259	2,586,099	390,081	2,976,180
Natural gas plant liquids	15,644	90,789	449,471	21,595	577,499	9,546	587,045
Receipts from other districts	1,225,330	957,560	101,122	33,957	7,558	59,419	--
Imports:							
Natural gasoline and plant condensate	2,237	14,066	218	5,624	22,145	2,263	24,408
Crude oil	517,840	366,107	651,511	19,878	1,555,336	379,806	1,935,142
Unfinished oils	7,721	16	3,750	--	11,487	248	11,735
Refined products	615,001	34,336	13,382	5,888	668,607	30,037	698,644
Other hydrocarbons and hydrogen refinery input	1,015	712	8,609	151	10,487	3,462	13,949
Total new supply	2,435,646	1,791,539	3,195,092	327,352	5,439,218	874,862	6,247,103
Crude oil unaccounted for	1,045	34,350	6,015	1,760	43,170	-15,091	28,079
Processing gain	25,374	56,713	57,161	3,668	142,916	31,759	174,675
Total supply	2,462,065	1,882,602	3,258,268	332,780	5,625,304	891,530	6,449,857
Change in stocks, all oils[1]	-13,944	-28,840	+25,397	+665	-16,722	-4,423	-21,145
Total disposition of supply	2,476,009	1,911,442	3,232,871	332,115	5,642,026	895,953	6,471,002
Exports:							
Crude oil	304	2,226	411	--	2,941	--	2,941
Refined products	5,250	3,351	42,917	69	51,587	27,074	78,661
Shipments to other districts	114,136	121,884	1,996,223	137,587	59,419	7,558	--
Crude oil losses[2]	442	1,282	3,000	120	4,844	421	5,265
Domestic demand for products:							
Gasoline:							
Motor gasoline	872,817	878,271	345,728	83,039	2,179,855	373,979	2,553,834
Aviation gasoline	2,766	3,684	3,134	777	10,361	3,001	13,362
Total gasoline	875,583	881,955	348,862	83,816	2,190,216	376,980	2,567,196
Jet fuel:							
Naphtha-type	19,205	13,443	14,597	3,052	50,297	22,416	72,713
Kerosine-type	113,082	54,827	26,634	9,811	204,354	84,291	288,645
Total jet fuel	132,287	68,270	41,231	12,863	254,651	106,707	361,358
Ethane (including ethylene)	5,203	16,321	108,147	2,531	132,202	505	132,707
Liquefied gases	71,295	137,611	135,064	16,437	360,407	20,856	381,263
Kerosine	29,651	17,829	10,582	717	58,779	3,141	61,920
Distillate fuel oil	509,485	360,981	131,975	41,624	1,044,065	101,580	1,145,645
Residual fuel oil	608,487	106,974	125,730	14,836	856,027	163,561	1,019,588
Petrochemical feedstocks	11,401	11,902	124,212	1,009	148,524	4,332	152,856
Special naphthas	8,413	10,109	8,373	108	27,003	3,103	30,106
Lubricants	22,075	12,917	14,431	798	50,221	5,511	55,732
Wax	1,928	1,368	2,852	175	6,323	887	7,210
Coke	12,123	34,109	25,451	3,036	74,719	14,372	89,091
Asphalt	36,248	55,735	22,750	11,268	126,001	20,762	146,763
Road oil	--	2,607	211	438	3,256	391	3,647
Still gas for fuel	21,214	45,882	73,425	4,474	144,995	35,671	180,666
Plant condensate	--	923	--	--	923	--	923
Miscellaneous products	10,484	17,206	17,024	209	44,923	2,541	47,464
Total domestic demand	2,355,877	1,782,699	1,190,320	194,339	5,523,235	860,900	6,384,135
Stocks for all oils:							
Crude oil and lease condensate	15,255	83,074	128,931	16,598	243,858	41,613	285,471
Unfinished oils	15,731	23,738	41,906	2,645	84,020	26,468	110,488
Natural gasoline and plant condensate	22	2,717	5,182	155	8,076	52	8,128
Refined products	203,969	184,411	229,999	17,971	636,350	71,373	707,723
Total	234,977	293,940	406,018	37,369	972,304	139,506	1,111,810

[1]Minus sign represents withdrawal from stocks, which is added to total disposition; plus sign represents stocks increase, which is subtracted from total disposition.
[2]Estimated for individual districts I through IV.

Table 5.—Supply and disposition of crude petroleum (including lease condensate) in the United States

(Thousand barrels)

Supply and disposition	1972	1973	1974	1975	1976[p]
Supply:					
Production	3,455,368	3,360,903	3,202,585	3,056,779	2,976,180
Imports[1]	811,135	1,183,996	1,269,155	1,498,181	1,935,142
Total new supply	4,266,503	4,544,899	4,471,740	4,554,960	4,911,322
Stocks changes:[2]					
Domestic crude	-17,064	-9,964	+13,758	+2,849	-146
Foreign crude	+3,811	+6,047	+8,784	+3,485	+14,263
Crude oil unaccounted for[3]	+10,201	+918	-9,084	+6,048	+28,079
Disposition by use:					
Runs of domestic crude	3,473,880	3,359,946	3,168,596	3,047,014	2,989,129
Runs of foreign crude	806,983	1,177,308	1,260,130	1,494,412	1,921,111
Exports[4]	187	697	1,074	2,146	2,941
Transfers:					
Distillate	944	760	774	587	540
Residual	3,322	6,126	4,751	5,616	6,298
Losses	4,641	4,897	4,789	4,899	5,265
Total disposition by use	4,289,957	4,549,734	4,440,114	4,554,674	4,925,284

[p]Preliminary (except for crude petroleum production).
[1]Bureau of Mines data.
[2]Minus represents withdrawal from stock; plus represents stock increase.
[3]Represents the difference between supply and indicated demand for crude petroleum.
[4]U.S. Department of Commerce data.

Table 6.—Production of crude petroleum (including lease condensate) in the United States, by State and month

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1975													
Alabama	1,172	965	1,140	1,082	1,141	1,079	1,148	1,152	1,115	1,127	1,193	1,163	13,477
Alaska	5,992	5,372	5,879	5,652	5,948	5,699	5,891	5,899	5,843	5,951	5,754	5,954	69,834
Arizona	63	51	57	54	54	54	53	55	51	53	45	45	635
Arkansas	1,308	1,239	1,263	1,319	1,364	1,322	1,459	1,342	1,310	1,458	1,329	1,420	16,133
California:													
South	10,603	9,579	10,551	10,155	10,507	10,235	10,578	10,423	10,014	10,316	9,934	10,134	123,029
Central coastal	6,283	5,607	6,199	6,046	6,245	6,041	6,193	6,178	5,984	6,172	5,870	6,125	72,943
East central	10,315	9,391	10,420	10,326	10,706	10,452	10,684	10,835	10,453	10,745	10,507	10,919	125,753
North	46	39	43	40	39	37	38	40	40	40	38	34	474
Total California	27,247	24,616	27,213	26,567	27,497	26,765	27,493	27,476	26,491	27,273	26,349	27,212	322,199
Colorado	2,924	2,800	3,174	3,444	3,307	3,220	3,293	3,208	3,175	3,226	3,076	3,242	38,089
Florida	3,262	3,058	3,478	3,556	3,529	3,532	3,645	3,561	3,386	3,710	3,528	3,637	41,877
Illinois	2,273	1,946	2,157	2,258	2,259	2,176	2,155	2,177	2,170	2,248	2,032	2,216	26,067
Indiana	385	336	359	362	378	371	513	358	387	403	354	426	4,632
Kansas	5,128	4,541	5,030	5,066	5,097	4,828	5,058	4,919	4,856	5,063	4,426	5,094	59,106
Kentucky	602	586	604	631	637	630	662	631	648	668	596	661	7,556
Louisiana:													
Gulf coast	53,390	50,444	53,309	52,184	52,218	51,092	51,715	50,486	47,606	51,506	49,583	49,969	613,502
Rest of State	3,238	2,977	3,125	2,928	3,018	2,948	3,138	3,251	3,072	3,217	3,131	3,295	37,338
Total Louisiana	56,628	53,421	56,434	55,112	55,236	54,040	54,853	53,737	50,678	54,723	52,714	53,264	650,840
Michigan	1,761	1,548	1,834	1,746	1,869	1,943	2,196	2,153	2,246	2,404	2,327	2,393	24,420
Mississippi	4,043	3,690	4,035	3,844	3,874	3,835	3,954	3,938	3,793	3,963	3,783	3,862	46,614
Missouri	5	4	5	5	5	4	5	5	5	5	4	5	57
Montana	2,768	2,548	2,854	2,701	2,767	2,682	2,707	2,793	2,777	2,779	2,694	2,774	32,844
Nebraska	515	462	503	506	529	523	539	523	509	520	486	505	6,120
Nevada	12	10	11	10	11	10	10	9	7	8	9	8	115
New Mexico:													
Southeastern	7,571	6,859	7,594	7,265	7,489	7,239	7,447	7,449	7,276	7,555	7,411	7,410	88,565
Northwestern	619	550	590	566	602	553	541	512	498	537	383	547	6,498
Total New Mexico	8,190	7,409	8,184	7,831	8,091	7,792	7,988	7,961	7,774	8,092	7,794	7,957	95,063
New York	86	67	74	74	74	69	74	70	71	68	75	73	875
North Dakota	1,636	1,532	1,992	1,208	1,695	1,676	1,774	1,800	1,758	1,798	1,772	1,811	20,452
Ohio	803	728	663	689	879	827	857	821	812	729	908	862	9,578

Table 6.—Production of crude petroleum (including lease condensate) in the United States, by State and month —Continued

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1975 —Continued													
Oklahoma	13,987	13,796	14,482	12,497	13,795	13,703	13,687	12,964	13,995	13,561	13,169	13,487	163,123
Pennsylvania	270	244	233	268	281	316	287	265	294	297	263	246	3,264
South Dakota	42	36	35	36	39	37	42	37	38	39	34	57	472
Tennessee	57	56	57	57	57	57	57	57	57	57	56	57	682
Texas:													
District 01	1,559	1,423	1,526	1,525	1,529	1,461	1,525	1,536	1,514	1,607	1,562	1,621	18,388
District 02	5,842	5,310	5,821	5,667	5,803	5,601	5,763	5,703	5,493	5,674	5,494	5,656	67,827
District 03	14,361	12,881	14,370	13,709	14,280	13,712	14,079	14,099	13,585	14,007	13,491	13,964	166,538
District 04	4,006	3,672	3,951	3,827	3,842	3,677	3,690	3,680	3,501	3,575	3,376	3,704	44,501
District 05	1,724	1,564	1,737	1,685	1,736	1,689	1,735	1,737	1,624	1,683	1,665	1,668	20,247
District 06, except East Texas	7,066	6,354	7,084	6,777	6,904	6,790	6,871	6,853	6,651	6,865	6,552	6,803	81,570
East Texas	5,996	5,370	5,954	5,717	5,895	5,689	5,804	5,763	5,657	5,786	5,587	5,806	69,024
District 07B	2,940	2,684	3,008	2,936	3,020	2,888	2,961	2,953	2,850	2,967	2,849	2,959	35,015
District 07C	3,341	3,019	3,394	3,256	3,299	3,172	3,270	3,300	3,224	3,367	3,244	3,339	39,225
District 08	21,460	19,422	21,701	20,903	21,319	20,410	20,990	21,053	20,379	21,309	20,391	20,913	250,250
District 08A	31,344	28,304	31,671	30,522	31,534	30,254	31,419	31,318	30,410	31,166	30,573	31,463	369,978
District 09	3,414	3,039	3,379	3,274	3,300	3,182	3,234	3,216	3,109	3,267	3,108	3,246	38,768
District 10	1,785	1,610	1,789	1,747	1,763	1,679	1,705	1,693	1,661	1,744	1,643	1,779	20,598
Total Texas	104,838	94,652	105,385	101,545	104,224	100,204	103,046	102,904	99,658	103,017	99,535	102,921	1,221,929
Utah	3,608	3,356	3,711	3,576	3,604	3,593	3,640	3,593	3,477	3,516	3,285	3,342	42,301
Virginia	1	--	--	--	1	--	--	--	1	--	--	--	3
West Virginia	226	199	204	227	212	209	216	186	183	213	183	221	2,479
Wyoming	12,272	11,289	12,247	11,775	11,288	11,428	11,106	11,118	10,824	11,088	10,563	10,945	135,943
Total United States:													
1975	262,104	240,552	263,297	253,698	259,742	252,624	258,408	255,712	248,389	258,057	248,336	255,860	3,056,779
1974	276,950	255,982	277,927	268,619	276,228	263,407	272,184	269,665	253,288	266,949	257,064	264,322	3,202,585
Daily average, 1975	8,455	8,591	8,493	8,457	8,379	8,421	8,366	8,249	8,280	8,324	8,278	8,254	8,375
Pennsylvania grade (included in U.S. total)	1,128	1,005	962	1,038	1,164	1,157	1,160	1,080	1,100	1,074	1,139	1,127	13,134
1976													
Alabama	1,093	906	1,096	1,119	1,257	1,212	1,330	1,270	1,221	1,445	1,390	1,367	14,706
Alaska	5,997	5,553	5,882	4,779	4,607	4,499	5,299	5,375	5,172	5,537	5,260	5,438	63,398
Arizona	50	47	45	44	47	42	42	41	42	41	38	40	519
Arkansas	1,399	1,339	1,443	1,444	1,493	1,513	1,595	1,582	1,579	1,588	1,565	1,557	18,097

California:													
South	10,065	9,461	9,915	9,383	9,697	9,285	9,279	9,312	8,928	9,227	8,811	9,088	112,451
Central coastal	6,052	5,569	5,923	5,720	5,894	5,676	5,790	5,756	5,542	5,745	5,538	5,773	68,978
East central	11,048	10,424	11,246	10,881	11,346	10,917	12,140	12,720	12,306	13,066	13,535	14,544	144,173
North	39	35	38	35	36	35	34	35	34	33	31	34	419
Total California	27,204	25,489	27,122	26,019	26,973	25,913	27,243	27,823	26,810	28,071	27,915	29,439	326,021
Colorado	3,187	3,010	3,411	2,966	3,293	3,106	3,237	3,314	3,294	3,485	3,358	3,331	38,992
Florida	3,615	3,433	3,615	3,538	3,648	3,590	3,755	3,912	3,768	3,933	3,808	3,845	44,460
Illinois	2,209	2,066	2,104	2,184	2,253	2,184	2,253	2,219	2,174	2,243	2,169	2,214	26,272
Indiana	376	342	407	393	403	414	403	258	409	395	409	421	4,630
Kansas	5,052	4,362	5,131	4,780	4,948	4,997	4,985	4,936	4,932	4,820	4,856	4,915	58,714
Kentucky	649	594	693	648	648	651	628	636	633	591	549	563	7,483
Louisiana:													
Gulf coast	49,716	45,585	49,394	46,175	48,819	47,569	48,750	48,103	46,686	45,725	45,028	46,724	568,274
Rest of State	3,250	3,130	3,277	3,130	3,189	3,180	3,267	3,191	3,171	3,195	3,124	3,123	38,227
Total Louisiana	52,966	48,715	52,671	49,305	52,008	50,749	52,017	51,294	49,857	48,920	48,152	49,847	606,501
Michigan	2,354	2,219	2,370	2,471	2,578	2,613	2,743	2,723	2,619	2,585	2,598	2,548	30,421
Mississippi	3,881	3,688	3,946	3,800	3,945	3,769	3,867	3,898	3,746	3,863	3,792	3,877	46,072
Missouri	5	5	5	5	5	5	5	5	5	5	5	6	61
Montana	2,731	2,609	2,802	2,705	2,816	2,663	2,755	2,797	2,648	2,734	2,736	2,818	32,814
Nebraska	507	490	526	515	538	523	519	511	524	515	492	522	6,182
Nevada	9	7	8	7	9	10	14	13	11	12	14	29	143
New Mexico:													
Southeastern	7,380	6,952	7,421	7,155	7,383	7,091	7,228	7,253	7,010	7,274	6,898	7,087	86,132
Northwestern	542	475	567	552	521	466	474	482	467	492	468	492	5,998
Total New Mexico	7,922	7,427	7,988	7,707	7,904	7,557	7,702	7,735	7,477	7,766	7,366	7,579	92,130
New York	86	68	62	69	67	73	62	86	73	76	71	64	857
North Dakota	1,797	1,755	1,821	1,772	1,861	1,765	1,807	1,739	1,823	1,868	1,829	1,888	21,725
Ohio	881	759	932	846	812	848	826	800	828	817	803	842	9,994
Oklahoma	13,329	13,960	13,884	12,596	14,028	13,267	13,460	13,374	13,656	13,562	13,184	13,126	161,426
Pennsylvania	253	229	268	282	292	271	263	272	265	244	204	176	3,019
South Dakota	34	37	38	39	39	33	33	38	35	39	37	45	447
Tennessee	46	44	44	43	39	43	56	70	58	35	54	66	598

Table 6.—Production of crude petroleum (including lease condensate) in the United States, by State and month —Continued

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1976 —Continued													
Texas:													
District 01	1,619	1,558	1,711	1,653	1,736	1,708	1,796	2,051	1,933	2,080	1,982	2,097	21,924
District 02	5,597	5,270	5,586	5,381	5,517	5,292	5,564	5,705	5,352	5,447	5,271	5,356	65,338
District 03	14,031	13,049	13,857	13,322	13,785	13,089	13,576	13,405	12,937	13,438	12,768	13,028	160,285
District 04	3,596	3,323	3,478	3,273	3,321	3,174	3,193	3,174	3,058	3,138	3,054	3,086	38,868
District 05	1,664	1,560	1,690	1,615	1,661	1,588	1,629	1,595	1,532	1,550	1,554	1,546	19,184
District 06, except East Texas	6,785	6,278	6,739	6,491	6,635	6,448	6,562	6,517	6,123	6,381	6,115	6,205	77,279
East Texas	5,789	5,381	5,756	5,536	5,702	5,546	5,654	5,618	5,447	5,635	5,427	5,596	67,087
District 07B	2,951	2,723	2,930	2,811	2,847	2,757	2,845	2,813	2,752	2,780	2,695	2,783	33,687
District 07C	3,299	3,087	3,360	3,204	3,334	3,156	3,254	3,221	3,112	3,309	3,162	3,348	38,846
District 08	20,922	19,612	20,834	19,900	20,630	19,788	21,783	21,644	21,094	21,957	20,965	21,650	250,779
District 08A	31,325	29,240	31,210	30,014	30,903	29,398	30,083	29,928	28,834	29,902	28,294	29,152	358,283
District 09	3,279	3,054	3,207	3,082	3,156	3,044	3,121	3,088	3,003	3,090	3,043	3,137	37,304
District 10	1,776	1,691	1,801	1,721	1,800	1,742	1,744	1,675	1,624	1,688	1,670	1,727	20,659
Total Texas	102,633	95,826	102,159	98,003	101,027	96,730	100,804	100,434	96,801	100,395	96,000	98,711	1,189,523
Utah	3,092	2,851	3,031	2,883	2,897	2,712	2,835	2,839	2,794	2,850	2,737	2,783	34,304
Virginia	--	--	--	1	--	--	--	1	--	--	--	1	3
West Virginia	191	191	225	228	213	220	205	223	214	205	196	208	2,519
Wyoming	11,637	10,684	11,469	11,119	11,212	10,861	11,199	11,211	11,021	11,322	10,801	11,613	134,149
Total United States:													
1976	255,185	238,705	255,198	242,310	251,860	242,833	251,942	251,429	244,489	249,962	242,388	249,879	2,976,180
1975	262,104	240,552	263,297	253,698	259,742	252,624	258,408	255,712	248,389	258,057	248,336	255,860	3,056,779
Daily average, 1976	8,232	8,231	8,232	8,077	8,125	8,094	8,127	8,111	8,150	8,063	8,080	8,061	8,132
Pennsylvania grade (included in U.S. total)	1,046	946	1,120	1,100	1,145	1,160	1,105	1,143	1,141	1,102	1,045	1,037	13,090

Sources of 1976 data:
Alabama—Alabama State Oil and Gas Board.
Alaska—Alaska Department of Natural Resources.
Arizona—Arizona Oil & Gas Commission.
Arkansas—Arkansas Oil and Gas Commission.
California—Division of Oil and Gas, California Department of Conservation.
Colorado—Colorado Oil and Gas Conservation Commission.
Florida—Florida Department of Natural Resources.
Illinois—Illinois State Geological Survey.
Indiana—Indiana Department of Natural Resources.
Kansas—Kansas Corporation Commission.
Kentucky—Kentucky Geological Survey.
Louisiana—Louisiana Department of Conservation and U.S. Geological Survey.
Michigan—Michigan Department of Natural Resources.
Mississippi—Mississippi State Oil and Gas Board.
Missouri—Missouri Geological Survey and Water Resources.
Montana—Montana Department of Natural Resources and Conservation.
Nebraska—Nebraska Oil and Gas Conservation Commission.
Nevada—Nevada Bureau of Mines and Geology.
New Mexico—New Mexico Oil Conservation Commission.
New York—New York State Geological Survey.
North Dakota—North Dakota Geological Survey.
Ohio—Ohio Department of Natural Resources.
Oklahoma—Oklahoma Corporation Commission and Oklahoma Tax Commission.
Pennsylvania—Pennsylvania Bureau of Topographic and Geologic Survey.
South Dakota—South Dakota Geological Survey.
Tennessee—Tennessee Department of Conservation.
Texas—The Railroad Commission of Texas.
Utah—Utah Oil and Gas Conservation Commission.
Virginia—Division of Mines and Quarries, Virginia Department of Labor and Industry.
West Virginia—West Virginia Department of Mines.
Wyoming—Wyoming State Oil and Gas Conservation Commission.

Table 7.—Percentage of total U.S. crude petroleum produced, by State

State	1972	1973	1974	1975	1976
Texas	37.7	38.5	39.4	40.0	40.0
Louisiana	25.8	24.7	23.0	21.3	20.4
California	10.0	10.0	10.1	10.5	11.0
Oklahoma	6.0	5.7	5.5	5.3	5.4
Wyoming	4.0	4.2	4.4	4.4	4.5
New Mexico	3.2	3.0	3.1	3.1	3.1
Alaska	2.1	2.2	2.2	2.3	2.1
Kansas	2.1	2.0	1.9	1.9	2.0
Mississippi	1.8	1.7	1.6	1.5	1.5
Utah	.8	1.0	1.2	1.4	1.2
Colorado	.9	1.1	1.2	1.2	1.3
Florida	.5	1.0	1.1	1.4	1.5
Montana	1.0	1.0	1.1	1.1	1.1
Illinois	1.0	.9	.9	.9	.9
North Dakota	.6	.6	.6	.7	.7
Michigan	.4	.4	.6	.8	1.0
Arkansas	.5	.5	.5	.5	.6
Alabama	.3	.3	.4	.4	.5
Ohio	.3	.3	.3	.3	.3
Other States	1.0	.9	.9	1.0	.9
Total	100.0	100.0	100.0	100.0	100.0

Table 8.—Well completions in the United States, by quarter[1]

	1st quarter	2nd quarter	3rd quarter	4th quarter	Total	
					Number	Percent
1975:						
Oil	3,742	3,525	4,012	5,129	16,408	44.0
Gas[2]	1,782	1,469	1,984	2,345	7,580	20.4
Dry	3,035	2,971	3,183	4,058	13,247	35.6
Total	8,559	7,965	9,179	11,532	37,235	100.0
1976:						
Oil	4,496	4,282	4,073	4,208	17,059	42.9
Gas[2]	2,266	2,061	2,380	2,378	9,085	22.8
Dry	3,465	3,211	3,196	3,749	13,621	34.3
Total	10,227	9,554	9,649	10,335	39,765	100.0

[1]Excludes service wells. Data by quarters adjusted to agree with annual totals.
[2]Includes condensate wells.

Source: American Petroleum Institute.

Table 9.—Well completions in the United States, by State and district[1]

State and district	1975				1976			
	Oil	Gas[2]	Dry	Total	Oil	Gas[2]	Dry	Total
Alabama	20	26	64	110	29	36	68	133
Alaska	44	4	15	63	50	1	11	62
Arizona	--	--	2	2	--	--	--	--
Arkansas	147	23	151	321	217	45	168	430
California	1,854	46	304	2,204	1,833	76	289	2,198
Colorado	328	300	563	1,191	415	178	454	1,047
Florida	15	--	31	46	11	--	19	30
Georgia	--	--	3	3	--	--	4	4
Idaho	--	--	1	1	--	--	2	2
Illinois	460	5	491	956	759	12	542	1,313
Indiana	145	17	211	373	191	23	271	485
Iowa	--	--	--	--	--	--	--	--
Kansas	1,094	438	1,527	3,059	1,473	540	1,694	3,707
Kentucky	304	123	491	918	381	151	541	1,073
Louisiana:								
North	402	413	413	1,228	454	808	454	1,716
South	373	220	569	1,162	294	211	535	1,040
Offshore	181	182	283	646	200	239	230	669
Total Louisiana	956	815	1,265	3,036	948	1,258	1,219	3,425
Maryland	--	--	1	1	--	2	--	2
Michigan	169	33	314	516	118	64	316	498
Mississippi	83	31	337	451	108	44	315	467
Missouri	6	1	15	22	6	7	10	23
Montana	100	279	531	910	91	190	391	672
Nebraska	74	1	263	338	87	2	233	322
Nevada	--	--	4	4	--	--	7	7
New Mexico:								
West	71	357	72	500	39	236	78	353
East	366	160	187	713	363	114	153	630
Total New Mexico	437	517	259	1,213	402	350	231	983
New York	142	236	16	394	133	355	67	555
North Carolina	--	--	2	2	--	--	--	--
North Dakota	69	--	138	207	93	--	141	234
Ohio	550	555	115	1,220	640	1,121	158	1,919
Oklahoma	1,743	638	1,265	3,646	1,991	790	1,435	4,216
Oregon	--	--	--	--	--	--	--	--
Pennsylvania	691	640	68	1,399	651	565	46	1,262
South Dakota	5	--	19	24	4	--	28	32
Tennessee	46	38	119	203	47	38	130	215
Texas:								
District 01	499	109	217	825	681	149	237	1,067
District 02	108	323	347	778	101	327	323	751
District 03	378	213	392	983	246	283	446	975
District 04	187	409	385	981	154	471	387	1,012
District 05	40	25	91	156	61	45	71	177
District 06	152	70	148	370	162	104	124	390
District 07B	570	227	686	1,483	541	261	759	1,561
District 07C	516	293	314	1,123	422	300	363	1,085
District 08	1,493	150	201	1,844	1,427	147	267	1,841
District 08A	931	16	243	1,190	687	38	248	973
District 09	982	84	528	1,594	1,061	124	648	1,833
District 10	218	204	165	587	233	179	107	519
Offshore	--	12	160	172	3	15	208	226
Total Texas	6,074	2,135	3,877	12,086	5,779	2,443	4,188	12,410
Utah	110	19	65	194	62	8	51	121
Virginia	2	26	8	36	--	7	4	11
Washington	--	--	--	--	--	--	3	3
West Virginia	120	556	115	791	124	699	85	908
Wyoming	620	78	565	1,263	416	80	470	966
Gulf of Mexico, northern[3]	--	--	32	32	--	--	30	30
Total United States	16,408	7,580	13,247	37,235	17,059	9,085	13,621	39,765

[1]Excludes service wells.
[2]Includes condensate wells.
[3]Gulf of Mexico, northern is a new area designated by the Bureau of Land Management for federally controlled Outer Continental Shelf (OCS) waters not previously mapped or leased. The area covers the Gulf of Mexico OSC waters off the States of Texas, Louisiana, Mississippi, Alabama, and Florida.

Source American Petroleum Institute.

Table 10.—Producing oil wells in the United States and average production per well per day,[1] by State

State	1975		1976	
	Approximate number of oil wells producing Dec. 31	Average production per well per day (barrels)	Approximate number of oil wells producing Dec. 31	Average production per well per day (barrels)
Alabama	608	62.1	633	64.8
Alaska	205	947.2	181	897.5
Arizona	28	65.7	27	51.6
Arkansas	7,308	6.1	7,529	6.7
California:				
South	8,758	38.1	9,230	33.2
Central coastal	6,108	33.0	5,910	31.8
East central	26,095	13.4	27,325	14.4
North	68	19.4	69	16.6
Total or average California	41,029	21.7	42,534	21.3
Colorado	2,450	45.1	2,827	40.4
Florida	143	822.4	143	849.5
Illinois	23,373	3.0	23,527	3.1
Indiana	4,798	2.8	4,891	2.6
Kansas	41,945	3.9	42,240	3.8
Kentucky	13,905	1.5	13,970	1.5
Louisiana:				
Gulf coast	[2]12,535	132.4	12,564	123.7
Northern	[2]15,199	6.7	13,710	7.2
Total or average Louisiana	[2]27,734	64.0	26,274	61.4
Michigan	3,655	17.0	3,770	22.4
Mississippi	[2]2,237	56.9	2,212	56.6
Montana	3,247	28.3	3,309	27.4
Nebraska	1,190	14.5	1,291	13.6
New Mexico:				
Southeastern	12,625	19.5	12,808	18.5
Northwestern	1,090	16.8	1,131	14.8
Total or average New Mexico	13,715	19.3	13,939	18.2
New York	[2]4,975	0.5	5,100	0.5
North Dakota	1,994	32.2	1,568	33.3
Ohio	16,611	1.6	16,761	1.6
Oklahoma	71,576	6.2	72,543	6.1
Pennsylvania	32,095	0.3	28,805	0.3
South Dakota	38	37.5	43	30.2
Tennessee	172	11.5	215	8.4
Texas:				
District 01	10,546	4.8	11,138	5.4
District 02	4,544	41.2	4,381	40.7
District 03	9,564	47.2	9,223	47.4
District 04	7,097	17.2	6,170	17.2
District 05	2,573	21.6	2,543	20.6
District 06, except East Texas	4,961	44.6	5,017	42.1
East Texas	12,902	14.5	12,612	14.5
District 07B	10,336	9.4	10,629	8.7
District 07C	7,564	14.3	8,023	13.2
District 08	36,337	19.0	35,969	19.0
District 08A	18,116	56.9	18,089	54.1
District 09	24,419	4.3	24,928	4.1
District 10	11,644	4.9	11,824	4.8
Total or average Texas	160,603	20.9	160,546	20.2
Utah	1,323	96.6	1,188	74.7
West Virginia	[2]13,750	0.5	13,800	0.5
Wyoming	[2]9,450	41.1	9,052	39.6
Other States:				
Missouri	163	1.0	173	1.0
Nevada	6	42.0	12	43.4
Virginia	7	1.6	7	1.2
Total or average	176	2.8	192	3.1
Total or average United States	500,333	16.8	499,110	16.3

[1]Based on the average number of wells during the year.
[2]Estimated by Bureau of Mines; all other data for producing oil wells furnished by State agencies.

Table 11.—Production and reserves of crude petroleum in leading fields in the United States

(Thousand barrels)

Field[1]	State	Production 1975	Production 1976	Total since discovery[2]	Estimated reserves
Wasson	Texas	93,763	91,226	1,064,112	444,464
Kelly-Snyder	do	72,706	67,844	900,345	449,655
East Texas	do	68,731	67,094	4,377,540	1,622,460
Wilmington	California	65,623	60,200	1,807,539	610,000
Slaughter	Texas	46,250	43,639	685,354	314,111
Hawkins	do	40,750	40,446	616,893	455,107
Midway Sunset	California	37,080	38,317	1,303,042	380,000
Jay	Florida	33,825	35,937	145,145	197,855
McArthur River	Alaska	41,132	35,174	329,391	173,000
Sho-Vel-Tum	Oklahoma	32,600	31,465	1,066,521	233,479
Eugene Island Block 330	Louisiana	27,903	31,192	99,583	131,659
Kern River	California	27,712	30,555	692,876	760,000
Hastings, East and West	Texas	27,936	27,512	558,439	197,764
Yates	do	18,093	27,476	651,015	948,987
Seminole All	do	23,929	26,514	269,790	189,210
Webster	do	25,075	25,158	463,191	175,767
Tom O'Connor	do	24,770	24,996	546,176	153,824
Bay Marchand Block 2	Louisiana	22,416	21,914	473,864	176,136
Conroe	Texas	21,375	21,091	583,125	153,875
Rangely	Colorado	20,481	20,656	554,765	158,512
Spraberry Trend	Texas	18,611	18,108	416,352	93,648
West Delta Block 30	Louisiana	17,731	16,768	346,961	103,039
Greater Altamont-Bluebell	Utah	22,115	16,382	85,595	308,618
Cowden, South (Foster, Johnson)	Texas	16,010	16,290	331,913	68,087
Levelland	do	13,830	15,767	262,105	92,895
Goldsmith All	do	16,475	15,705	610,838	164,162
Cowden North	do	16,479	15,666	308,965	132,855
Empire Abo	New Mexico	15,225	15,304	141,700	58,300
Van and Van Shallow	Texas	15,978	15,251	450,613	99,387
Huntington Beach	California	17,234	14,991	955,955	120,000
Grand Isle Block 43	Louisiana	17,592	14,781	196,042	174,030
Thompson All	Texas	15,294	13,340	398,705	101,295
McElroy	do	12,114	13,078	429,078	252,922
San Ardo	California	13,828	13,040	301,093	150,000
West Ranch	Texas	13,834	12,637	297,883	70,117
Caillou Island	Louisiana	14,035	12,479	543,412	178,486
Oregon Basin	Wyoming	11,305	12,445	265,302	112,871
Dos Cuadras	California	13,697	12,284	128,205	93,000
Salt Creek	Texas	11,726	12,234	150,623	79,377
Vacuum	New Mexico	12,519	11,822	299,327	100,673
Elk Hills	California	708	11,250	295,800	1,000,000
Cogdell Area	Texas	13,163	11,174	212,255	107,745
Panhandle	do	11,470	11,163	1,306,218	108,782
Belridge South	California	9,347	10,997	215,096	110,000
Ventura	do	11,286	10,841	815,474	86,000
South Pass Block 24	Louisiana	12,868	10,746	395,090	94,910
South Pass Block 61	do	3,619	9,918	20,925	81,193
West Delta Block 58	do	9,026	9,636	56,753	143,247
Sooner Trend	Oklahoma	9,140	9,550	218,104	45,896
Middle Ground Shoal	Alaska	8,584	8,983	105,316	80,000
Bell Creek	Montana	8,615	8,753	86,248	30,236
Fairway	Texas	11,214	8,675	143,592	69,345
Grand Isle Block 16	Louisiana	11,377	8,200	230,629	119,371
Greater Aneth	Utah	8,302	8,177	276,702	39,379
West Delta Block 73	Louisiana	8,268	8,035	144,522	130,478
Anton-Irish	Texas	7,416	7,831	88,974	25,865
Swanson River	Alaska	8,676	7,736	170,835	52,000
Fullerton All	Texas	7,127	7,442	252,986	138,431
Elk Basin (Wyoming and Montana)	Wyoming	8,007	7,407	464,160	79,240
Ship Shoal Block 208	Louisiana	8,361	7,378	108,245	116,755
Howard Glasscock	Texas	6,979	7,300	324,432	66,568
South Pass Block 65	Louisiana	8,471	7,114	61,778	128,222
Salt Creek	Wyoming	9,839	7,041	559,407	60,144

[1]Fields under 7 million barrels not shown for current year.
[2]Includes revisions, if any.

Source: Oil and Gas Journal. All figures are preliminary.

Table 12.—Estimates of proved crude oil reserves in the United States on December 31, by State[1]

(Million barrels)

State	1972	1973	1974	1975	1976
Eastern States:					
Illinois	175	152	160	161	155
Indiana	29	27	24	22	22
Kentucky	48	40	37	39	38
Michigan	62	72	82	93	139
New York	9	8	11	10	9
Ohio	127	125	124	121	125
Pennsylvania	37	40	50	48	51
West Virginia	34	32	32	32	30
Total	521	496	520	526	569
Central and southern States:					
Alabama	57	54	69	61	53
Arkansas	113	106	106	96	93
Florida	208	184	303	263	250
Kansas	453	401	395	364	362
Louisiana[2]	5,029	4,577	4,227	3,827	3,471
Mississippi	313	291	261	231	214
Nebraska	31	28	27	28	31
New Mexico	583	643	625	588	536
North Dakota	166	179	173	158	150
Oklahoma	1,303	1,271	1,232	1,240	1,187
Texas[2]	12,144	11,757	11,002	10,080	9,226
Total	20,400	19,491	18,420	16,936	15,573
Mountain States:					
Colorado	326	305	289	276	252
Montana	241	219	207	164	153
Utah	244	264	251	208	183
Wyoming	950	917	903	877	828
Total	1,761	1,705	1,650	1,525	1,416
Pacific coast States:					
Alaska	10,096	10,112	10,094	10,037	9,786
California[2]	3,554	3,488	3,557	3,648	3,590
Total[1]	13,650	13,600	13,651	13,685	13,376
Other States[3]	7	8	9	10	8
Total United States	36,339	35,300	34,250	32,682	30,942

[1]From reports of Committee of Petroleum Reserves, American Petroleum Institute. Included are estimated quantities known reservoirs under existing economic and operating conditions.
[2]Includes offshore reserves.
[3]Includes Arizona, Missouri, Nevada, South Dakota, Tennessee, and Virginia.

Table 13.—Refinery receipts of domestic

(Thousand

Location of refineries receiving crude oil	Total receipts of domestic crude oil	Intrastate receipts	Interstate: District I, Total	Interstate: District II: Ill., Ind., Mich.	Kans.	Ky., Ohio, Tenn.	Nebr., N.Dak S.Dak.	Okla.	Total
District I:									
Delaware and Maryland	2,060	--	448	--	--	--	--	--	--
Florida, Georgia, Virginia	812	20	--	--	--	--	--	--	--
New Jersey	9,864	--	1,373	--	--	--	--	--	--
New York	17,530	--	--	3,853	--	--	--	311	4,164
Pennsylvania:									
East	9,238	--	149	--	--	--	--	--	--
West	15,909	3,278	1,041	1,405	775	6,226	--	959	9,365
West Virginia	6,061	2,476	--	--	--	3,585	--	--	3,585
Total	61,474	5,774	3,011	5,258	775	9,811	--	1,270	17,114
District II:									
Illinois	243,892	15,369	247	--	719	--	1,853	20,944	23,516
Indiana	141,545	1,338	255	2,924	3,987	809	6,024	16,644	30,388
Kansas	129,010	54,877	--	--	--	--	794	21,321	22,115
Kentucky and Tennessee	39,221	3,526	4,547	7,251	--	611	--	61	7,923
Michigan	34,327	22,123	--	87	--	--	--	--	87
Minnesota and Wisconsin	26,884	--	--	--	--	--	7,097	1,976	9,073
Missouri and Nebraska	32,058	66	--	--	--	--	72	1,227	1,299
North Dakota	15,647	14,362	--	--	--	--	--	--	--
Ohio:									
East	6,908	64	--	671	--	--	--	--	671
West	120,693	85	303	10,599	--	--	--	--	10,599
Oklahoma	165,083	116,512	--	--	1,736	--	--	--	1,736
Total	955,268	228,322	5,352	21,532	6,442	1,420	15,840	62,173	107,407
District III:									
Alabama	26,883	3,062	16,252	--	--	485	--	--	485
Arkansas	20,065	14,403	--	--	--	--	--	--	--
Louisiana	465,607	364,405	15,988	--	--	--	--	1	1
Mississippi	55,925	15,695	368	--	--	--	--	--	--
New Mexico	29,892	29,332	--	--	--	--	--	--	--
Texas	851,712	727,736	2,921	--	1,230	--	--	7,214	8,444
Total	1,450,084	1,154,633	35,529	--	1,230	485	--	7,215	8,930
District IV:									
Colorado	17,982	7,526	--	--	--	--	--	--	--
Montana	27,134	10,067	--	--	--	--	5	--	5
Utah	44,848	18,419	--	--	--	--	--	--	--
Wyoming	53,159	51,816	--	--	--	--	--	--	--
Total	143,123	87,828	--	--	--	--	5	--	5
District V:									
California	352,743	308,538	--	--	--	--	--	--	--
Other States	27,123	19,804	--	--	--	--	--	--	--
Total	379,866	328,342	--	--	--	--	--	--	--
Total United States	2,989,815	1,804,898	[1]44,892	26,790	8,447	11,716	15,845	70,658	133,456
Daily average	8,169	4,931	123	73	23	32	43	193	364

[1]Florida, 43,786; New York, 1,028; West Virginia, 78.
[2]Alaska, 42,654; California, 2,336; Nevada, 123; Arizona, 45.

crude oil in 1976, by State and PAD district

barrels)

receipts from											
District III					District IV					Dis-trict V total	Total inter-state receipts
Ala., Ark., Miss.	La.	N. Mex.	Tex.	Total	Colo.	Mont.	Utah	Wyo.	Total		
--	--	--	1,612	1,612	--	--	--	--	--	--	2,060
705	87	--	--	792	--	--	--	--	--	--	792
--	1,586	--	6,905	8,491	--	--	--	--	--	--	9,864
--	6,154	--	7,060	13,214	--	--	--	152	152	--	17,530
193	526	--	8,370	9,089	--	--	--	--	--	--	9,238
--	911	--	904	1,815	--	368	--	42	410	--	12,631
--	--	--	--	--	--	--	--	--	--	--	3,585
898	9,264	--	24,851	35,013	--	368	--	194	562	--	55,700
2,953	38,633	25,688	116,201	183,475	1,089	7,713	1,086	11,397	21,285	--	228,523
--	14,633	12,195	58,835	85,663	630	7,422	--	15,849	23,901	--	140,207
--	672	--	28,898	29,570	3,515	935	53	17,945	22,448	--	74,133
212	16,942	--	5,187	22,341	--	--	--	884	884	--	35,695
--	3,347	--	193	3,540	--	--	--	8,577	8,577	--	12,204
--	100	--	15,682	15,782	--	2,029	--	--	2,029	--	26,884
--	--	2,404	26,065	28,469	15	1,268	--	941	2,224	--	31,992
--	--	--	--	--	--	1,285	--	--	1,285	--	1,285
--	4,391	--	1,764	6,155	--	--	--	18	18	--	6,844
4,106	43,928	1,765	55,878	105,677	--	225	--	3,804	4,029	--	120,608
--	44	1,766	43,959	45,769	311	--	755	--	1,066	--	48,571
7,271	122,690	43,818	352,662	526,441	5,560	20,877	1,894	59,415	87,746	--	726,946
7,085	--	--	--	7,085	--	--	--	--	--	--	23,822
--	956	--	4,706	5,662	--	--	--	--	--	--	5,662
11,586	--	--	73,627	85,213	--	--	--	--	--	--	101,202
--	39,862	--	--	39,862	--	--	--	--	--	--	40,230
1	--	--	--	1	265	--	257	--	522	37	560
15,505	77,770	13,599	--	106,874	1,486	--	3,251	--	4,737	--	123,976
34,177	118,588	13,599	78,333	244,697	1,751	--	3,508	--	5,259	37	295,452
--	--	--	--	--	--	83	3,037	7,336	10,456	--	10,456
--	--	--	--	--	--	--	--	17,062	17,062	--	17,067
--	--	--	91	91	18,512	--	--	7,818	26,330	8	26,429
--	--	--	--	--	1,214	26	103	--	1,343	--	1,343
--	--	--	91	91	19,726	109	3,140	32,216	55,191	8	55,295
--	--	--	--	--	140	--	5,792	--	5,932	38,273	44,205
--	--	--	--	--	--	1	478	--	479	6,840	7,319
--	--	--	--	--	140	1	6,270	--	6,411	45,113	51,524
42,346	250,542	57,417	455,937	806,242	27,177	21,355	14,812	91,825	155,169	[2]45,158	1,184,917
116	685	157	1,246	2,204	74	58	40	251	423	123	3,238

Table 14.—Supply, demand, and stocks change of refined products, in 1976

(Thousand barrels per day)

	PAD district						United States
	I	II	III	IV	I-IV	V	
Supply:							
Refinery output	1,700	3,757	5,832	459	11,748	2,166	13,914
Natural gas liquids output	43	248	1,228	58	1,577	27	1,604
Unfinished oil reruns	-45	-1	41	-7	-12	-8	-20
Other hydrocarbons and crude transfers	3	4	29	1	37	20	57
Receipts from other districts:							
District I	--	197	--	--	--	--	--
District II	72	--	127	64	--	--	--
District III	3,131	701	--	11	--	76	--
District IV	--	26	8	--	--	68	--
District V	--	--	2	18	20	--	--
Imports	1,707	132	48	32	1,919	89	2,008
Total new supply	6,611	5,064	7,315	636	15,289	2,438	17,563
Stock change[1]	-37	-79	+25	+3	-88	-8	-96
Total supply	6,648	5,143	7,290	633	15,377	2,446	17,659
Exports	14	9	118	--	141	74	215
Shipments to other districts:							
District I	--	72	3,131	--	--	--	--
District II	197	--	701	26	--	--	--
District III	--	127	--	8	--	2	--
District IV	--	64	11	--	--	18	--
District V	--	--	76	68	144	--	--
Domestic product demand	6,437	4,871	3,253	531	15,092	2,352	17,444

[1]Plus sign represents a stock increase, which is subtracted from total new supply; minus sign represents a stocks decrease, which is added to total new supply.

Table 15.—Crude oil input to refineries and refinery receipts of crude oil by origin of the crude and method of transportation, in 1976

(Thousand barrels)

District and State	Crude oil input to refineries	Refinery fuel use and losses	By State of origin of domestic crude	Change in refinery stocks	Refinery receipts of domestic crude oil by receiving State and method of transportation: Interstate			Intrastate			Refinery receipts of foreign crude	
					Pipelines	Tank cars and trucks	Tankers and barges	Pipelines	Tank cars and trucks	Tankers and barges	Pipelines	Tankers and barges
District I:												
Delaware and Maryland	57,513	20	--	+481	--	--	--	--	--	2,060	--	55,954
Florida, Georgia, Virginia	23,657	23	43,806	+596	--	20	--	--	792	--	--	23,464
New Jersey and Rhode Island	213,286	-1	--	-889	--	--	--	--	--	9,864	--	202,532
New York and New Hampshire	36,178	5	1,028	-55	--	--	--	17,530	--	--	15,415	3,183
Pennsylvania:												
East	220,183	10	--	-903	--	--	--	--	--	9,238	--	210,052
West	23,292	7	3,278	-150	1,675	1,603	--	6,253	4,615	1,763	6,583	657
West Virginia	6,120	2	2,554	-61	2,427	49	--	1,579	602	1,404	--	--
Total	[1]580,229	66	50,666	-981	4,102	1,672	--	25,362	6,009	24,329	21,998	495,842
District II:												
Illinois	372,913	10	33,381	+75	15,350	19	--	228,523	--	--	129,106	--
Indiana	176,757	8	1,338	-191	1,317	21	--	138,219	34	1,954	34,149	880
Kansas	145,604	56	63,324	+324	52,555	2,322	--	74,040	93	--	16,974	--
Kentucky and Tennessee	71,636	82	5,318	+53	2,514	1,012	--	21,958	567	13,170	32,095	455
Michigan	45,417	1	30,901	-59	20,398	1,725	--	12,204	--	--	11,032	--
Minnesota and Wisconsin	75,079	19	--	-341	--	--	--	26,884	--	--	47,873	--
Missouri and Nebraska	32,137	--	6,867	+113	14	52	--	31,992	--	--	192	--
North Dakota and South Dakota	18,933	-1	23,406	+14	13,812	550	--	1,276	9	--	3,299	--
Ohio:												
East	22,750	--	64	+187	64	--	--	6,844	--	--	16,029	--
West	[2]169,865	-1	10,009	+4	85	--	--	120,608	--	--	[2]49,175	--
Oklahoma	186,504	21	187,170	+38	112,096	4,416	--	48,571	--	--	21,480	--
Total	1,317,595	195	361,778	+217	218,205	10,117	--	711,119	703	15,124	361,404	1,335

See footnotes at end of table.

Table 15.—Crude oil input to refineries and refinery receipts of crude oil by origin of the crude and method of transportation, in 1976—Continued

(Thousand barrels)

District and State	Crude oil input to refineries	Refinery fuel use and losses	By State of origin of domestic crude	Change in refinery stocks	Refinery receipts of domestic crude oil by receiving State and method of transportation: Interstate			Intrastate			Refinery receipts of foreign crude	
					Pipelines	Tank cars and trucks	Tankers and barges	Pipelines	Tank cars and trucks	Tankers and barges	Pipelines	Tankers and barges
District III:												
Alabama	27,638	-76	13,863	+298	970	668	1,423	17,879	145	5,798	--	977
Arkansas	19,827	183	15,175	+55	13,536	867	--	5,646	16	--	--	--
Louisiana	601,124	182	614,947	+4,246	283,289	5,513	75,603	88,013	1,757	11,432	--	139,893
Mississippi	109,744	49	46,467	+529	13,824	1,871	--	40,213	17	--	--	54,397
New Mexico	29,724	30	86,749	+138	25,283	3,942	107	--	560	--	--	--
Texas	1,304,452	77	1,183,673	+3,245	704,590	12,268	10,878	77,674	339	45,963	9,211	446,903
Total	2,092,509	445	1,960,874	+8,511	1,041,492	25,129	88,011	229,425	2,834	63,193	9,211	642,170
District IV:												
Colorado	17,966	1	34,703	+15	4,948	2,578	--	7,476	2,980	--	--	--
Montana	44,325	--	31,422	+342	8,513	1,554	--	17,056	11	--	17,533	--
Utah	44,907	7	33,231	-66	15,064	3,355	--	24,994	1,435	--	--	--
Wyoming	54,386	3	143,641	-153	50,431	1,385	--	992	351	--	1,077	--
Total	161,584	11	242,997	+138	78,956	8,872	--	50,518	4,777	--	18,610	--
District V:												
California	608,321	362	310,874	+594	260,458	12,235	35,845	3,694	3,126	37,385	--	256,534
Washington	109,087	9	9	+289	--	--	9	--	--	6,167	31,803	71,406
Other States[3]	40,915	50	62,617	+45	19,407	322	66	--	525	627	--	20,063
Total	758,323	421	373,500	+928	279,865	12,557	35,920	3,694	3,651	44,179	31,803	348,003
Total United States	4,910,240	1,138	2,989,815	+8,813	1,622,620	58,347	123,931	1,020,118	17,974	146,825	[4]443,026	1,487,350
Daily Average	13,416	3	8,169	+24	4,433	159	338	2,787	49	401	1,210	4,064

[1]Includes 337,499,000 barrels in Delaware River Valley.
[2]Includes some Athabasca hydrocarbons.
[3]Alaska, Arizona, Hawaii, Nevada, Oregon.
[4]Excludes crude oil imported for direct burning for fuel use by pipeline.

Table 16.—Supply and distribution of crude oil, in 1976

(Thousand barrels per day)

	PAD district						United States
	I	II	III	IV	I-IV	V	
Crude oil supply:							
Domestic production including lease condensate	139	896	5,374	657	7,066	1,066	8,132
Receipts from other districts:							
District I	--	15	100	--	--	--	--
District II	47	--	24	--	--	--	--
District III	96	1,438	--	--	--	--	--
District IV	1	240	15	--	--	17	--
District V	--	--	--	--	--	--	--
Imports	1,415	1,000	1,780	54	4,249	1,038	5,287
Total new supply	1,698	3,589	7,293	711	11,315	2,121	13,419
Stocks change[1]	-2	--	+44	--	+42	-4	+38
Total supply	1,700	3,589	7,249	711	11,273	2,125	13,381
Crude oil distribution:							
Crude runs to stills	1,586	3,600	5,717	441	11,344	2,072	13,416
Transfers to products	--	2	6	1	9	10	19
Shipments to other districts:							
District I	--	47	96	1	--	--	--
District II	15	--	1,438	240	--	--	--
District III	100	24	--	15	--	--	--
District IV	--	--	--	--	--	--	--
District V	--	--	--	17	17	--	--
Exports	1	6	1	--	8	--	8
Losses	1	4	8	--	13	1	14
Crude oil unaccounted for	3	94	17	4	118	-42	76

[1]Plus sign represents a stock increase, which is subtracted from total supply; minus sign represents a stock decrease, which is added to total new supply.

Table 17.—Supply and disposition of crude petroleum (including lease condensate) in the United States, by month

(Thousand barrels)

Supply and disposition	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1975													
Supply:													
Production	262,104	240,552	263,297	253,698	259,742	252,624	258,408	255,712	248,389	258,057	248,336	255,860	3,056,779
Imports[1]	124,901	107,194	113,345	101,338	108,072	117,142	129,966	142,016	140,675	136,068	138,703	138,761	1,498,181
Total new supply	387,005	347,746	376,642	355,036	367,814	369,766	388,374	397,728	389,064	394,125	387,039	394,621	4,554,960
Change in stocks, end of period:													
Domestic crude	+1,129	+4,068	+5,208	+4,468	-2,568	-4,820	-9,418	-7,324	+289	+8,645	+1,745	+1,427	+2,849
Foreign crude	+4,313	+2,225	-1,974	-2,549	+1,621	-9	-2,557	-217	+2,541	+1,493	-379	-1,023	+3,485
Unaccounted for[2]	+1,301	+55	-3,214	+1,840	+3,633	-1,196	+1,063	+44	+3,259	+280	-3,918	+2,901	+6,048
Disposition by use:													
Runs of domestic crude	260,626	234,831	253,763	250,253	265,044	255,368	267,858	262,284	250,231	248,760	241,607	256,389	3,047,014
Runs of foreign crude	120,567	104,946	115,293	103,851	106,437	117,134	132,518	142,149	138,113	134,569	139,072	139,763	1,494,412
Exports[3]	836	942	349	19	--	--	--	--	--	--	--	--	2,146
Transfers:													
Distillate	53	48	49	59	61	43	47	47	49	43	43	45	587
Residual	371	371	341	391	451	451	559	399	682	482	623	495	5,616
Losses	411	370	399	384	401	403	430	434	418	413	410	426	4,899
Total disposition by use	382,864	341,508	370,194	354,957	372,394	373,399	401,412	405,313	389,493	384,267	381,755	397,118	4,554,674
1976[p]													
Supply:													
Production	255,185	238,705	255,198	242,310	251,860	242,833	251,942	251,429	244,489	249,962	242,388	249,879	2,976,180
Imports[1]	142,427	122,030	146,879	143,687	144,748	168,641	179,540	172,221	176,237	176,679	178,367	183,686	1,935,142
Total new supply	397,612	360,735	402,077	385,997	396,608	411,474	431,482	423,650	420,726	426,641	420,755	433,565	4,911,322
Change in stocks, end of period:													
Domestic crude	+13,552	-6,909	+3,004	-997	+749	-7,560	-2,651	-4,719	+1,950	+13,689	-1,735	-8,519	-146
Foreign crude	+4,390	-4,973	+2,694	+4,513	-3,395	+5,293	+3,535	-608	+5,135	-363	+2,888	-4,846	+14,263
Unaccounted for[2]	+10,716	+508	+3,837	+300	+2,252	+1,238	+1,347	+2,925	-1,137	+1,184	+5,395	-486	+28,079
Disposition by use:													
Runs of domestic crude	251,367	245,176	255,030	242,648	252,337	250,450	254,959	257,710	240,410	236,200	247,044	255,798	2,989,129

Runs of foreign crude	138,006	126,998	144,162	139,162	148,179	163,525	175,969	172,819	171,076	176,696	175,995	188,524	1,921,111
Exports[3]	--	--	45	--	1	--	--	380	--	563	900	1,052	2,941
Transfers:													
Distillate	44	42	46	48	43	43	47	47	49	43	43	45	540
Residual	550	507	504	512	516	518	510	486	528	554	562	551	6,298
Losses	419	402	429	411	430	443	460	460	441	443	453	474	5,265
Total disposition by use	390,386	373,125	400,216	382,781	401,506	414,979	431,945	431,902	412,504	414,499	424,997	446,444	4,925,284

[p]Preliminary except for crude petroleum production.
[1]Reported to the Bureau of Mines. Imports of crude oil include some Athabasca hydrocarbons.
[2]Represents the difference between supply and indicated demand for crude petroleum.
[3]U.S. Department of Commerce.

Table 18.—Input and output of petroleum products at refineries in the United States

(Thousand barrels)

	1972	1973	1974	1975	1976[p]
INPUT					
Crude petroleum:					
Domestic	3,473,880	3,359,946	3,168,596	3,047,014	2,989,129
Foreign[1]	806,983	1,177,308	1,260,130	1,494,412	1,921,111
Total crude petroleum	4,280,863	4,537,254	4,428,726	4,541,426	4,910,240
Unfinished oils rerun (net)	+51,518	+45,768	+37,351	+12,664	+7,599
Total crude and unfinished oils rerun	4,332,381	4,583,022	4,466,077	4,554,090	4,917,839
Natural gas liquids:					
Liquefied petroleum gases	85,193	80,221	80,217	89,662	95,260
Natural gasoline	164,062	160,350	147,603	134,087	132,320
Plant condensate	53,190	56,911	44,596	35,570	37,871
Total natural gas liquids	302,445	297,482	272,416	259,319	265,451
Other hydrocarbons and hydrogen[2]	10,118	10,716	13,057	13,779	13,949
OUTPUT					
Gasoline:					
Motor gasoline[3]	2,298,775	2,382,418	2,320,488	2,378,960	2,502,711
Aviation gasoline	16,993	16,413	15,895	13,718	13,332
Total gasoline[3]	2,315,768	2,398,831	2,336,383	2,392,678	2,516,043
Jet fuel:					
Naphtha-type[3]	76,565	65,997	71,175	65,620	68,472
Kerosine-type	233,464	247,692	233,889	252,361	267,374
Total jet fuel[3]	310,029	313,689	305,064	317,981	335,846
Ethane (including ethylene)	9,197	9,194	6,330	4,055	5,639
Liquefied refinery gas:					
For fuel use	84,514	89,570	81,561	80,514	84,223
For chemical use	36,668	38,062	35,433	28,819	34,706
Total liquefied refinery gas	121,182	127,632	116,994	109,333	118,929
Kerosine[3]	79,027	79,422	56,646	55,495	55,591
Distillate fuel oil[3]	962,405	1,029,343	973,764	968,436	1,070,032
Residual fuel oil	292,519	354,597	390,491	450,957	503,953
Petrochemical feedstocks:					
Still gas	14,678	12,428	14,375	15,723	17,448
Naphtha-400°	57,027	57,155	62,568	54,770	80,093
Other	52,321	62,981	57,821	51,694	66,879
Total petrochemical feedstocks	124,026	132,564	134,764	122,187	164,420
Special naphthas[3]	32,096	32,873	33,362	27,200	32,618
Lubricants	65,349	68,742	70,694	56,221	61,803
Wax (280 pounds = 1 barrel)	6,148	6,768	6,929	5,665	7,008
Coke (1 short ton = 5.0 barrels)	119,765	132,290	123,746	129,241	130,145
Asphalt (1 short ton = 5.5 barrels)	155,294	167,884	164,237	143,957	139,706
Road oil	7,943	7,326	7,162	4,944	3,240
Still gas for fuel	170,993	176,758	175,724	175,351	180,666
Miscellaneous[3]	15,364	18,795	24,515	31,269	46,275
Processing gain (-) or loss (+)	-142,161	-165,488	-175,255	-167,782	-174,675

[p]Preliminary.
[1]Includes some Athabasca hydrocarbons.
[2]"Other hydrocarbons and hydrogen" is defined as including all hydrogen, process natural gas, tar sand bitumen, gilsonite, shale oil, and other naturally occurring hydrocarbon mixtures consumed as raw materials in the production of finished products.
[3]Production at gas-processing plants shown as direct transfers and omitted from the input and output at refineries.

Table 19.—Percentage yields of refined petroleum products from crude oil in the United States[1]

Finished products	1972	1973	1974	1975	1976[p]
Gasoline	46.2	45.6	45.9	46.5	45.5
Jet fuel	7.2	6.8	6.8	7.0	6.8
Ethane (including ethylene)	.2	.2	.1	.1	.1
Liquefied gases	2.8	2.8	2.6	2.4	2.4
Kerosine	1.8	1.7	1.3	1.2	1.1
Distillate fuel oil	22.2	22.5	21.8	21.3	21.8
Residual fuel oil	6.8	7.7	8.7	9.9	10.3
Petrochemical feedstocks	2.9	2.9	3.0	2.7	3.3
Special naphthas	.7	.7	.8	.6	.7
Lubricants	1.5	1.5	1.6	1.2	1.3
Wax	.1	.2	.2	.1	.1
Coke	2.8	2.9	2.8	2.8	2.6
Asphalt	3.6	3.6	3.7	3.2	2.8
Road oil	.2	.2	.2	.1	--
Still gas	3.9	3.9	3.9	3.9	3.7
Miscellaneous	.4	.4	.5	.7	1.0
Shortage	-3.3	-3.6	-3.9	-3.7	-3.5
Total	100.0	100.0	100.0	100.0	100.0

[p]Preliminary.
[1]Other unfinished oils added to crude in computing yields.

Table 20.—Input and output at refineries in the United States, by month

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
INPUT 1975													
Crude petroleum:													
Domestic	260,626	234,831	253,763	250,253	265,044	255,368	267,858	262,284	250,231	248,760	241,607	256,389	3,047,014
Foreign	120,567	104,946	115,293	103,851	106,437	117,134	132,518	142,149	138,113	134,569	139,072	139,763	[1]1,494,412
Total crude petroleum	381,193	339,777	369,056	354,104	371,481	372,502	400,376	404,433	388,344	383,329	380,679	396,152	4,541,426
Unfinished oils rerun (net)	+9,464	-371	-2,833	-2,909	-6,010	+3,608	+4,379	-1,113	+4,201	+2,259	-1,604	+3,593	+12,664
Total crude and unfinished oils rerun	390,657	339,406	366,223	351,195	365,471	376,110	404,755	403,320	392,545	385,588	379,075	399,745	4,554,090
Natural gas liquids:													
Liquefied petroleum gases	9,431	7,732	7,658	5,991	5,637	5,483	6,283	6,266	7,220	8,105	9,390	10,466	89,662
Natural gasoline	10,640	10,279	11,395	10,824	11,200	11,178	12,051	12,049	10,975	11,891	10,814	10,791	134,087
Plant condensate	3,371	2,542	3,608	3,204	2,637	3,123	3,394	3,082	2,888	2,594	2,578	2,549	35,570
Total natural gas liquids	23,442	20,553	22,661	20,019	19,474	19,784	21,728	21,397	21,083	22,590	22,782	23,806	259,319
Other hydrocarbons and hydrogen	946	850	775	1,110	1,128	1,214	1,498	1,326	1,116	1,303	1,349	1,164	13,779
OUTPUT 1975													
Gasoline:													
Motor gasoline[2]	201,768	175,727	188,167	181,377	189,918	200,082	217,088	213,024	204,675	198,697	198,070	210,367	2,378,960
Aviation gasoline	1,110	910	923	884	1,107	1,052	1,330	1,482	1,264	1,524	1,294	838	13,718
Total gasoline[2]	202,878	176,637	189,090	182,261	191,025	201,134	218,418	214,506	205,939	200,221	199,364	211,205	2,392,678
Jet fuel:													
Naphtha-type[2]	4,294	4,651	6,157	4,967	5,672	4,901	5,820	5,812	5,735	6,082	6,047	5,482	65,620
Kerosine-type	21,475	18,723	21,633	20,939	21,016	20,264	21,561	23,884	21,487	20,689	19,866	20,824	252,361
Total jet fuel[2]	25,769	23,374	27,790	25,906	26,688	25,165	27,381	29,696	27,222	26,771	25,913	26,306	317,981
Ethane (including ethylene)	422	305	278	326	336	355	319	359	329	321	352	353	4,055
Liquefied refinery gases:													
For fuel use	7,063	6,085	6,221	6,123	6,815	6,578	7,295	7,749	6,635	6,867	6,393	6,690	80,514
For chemical use	2,043	1,886	2,174	1,735	2,115	2,768	2,811	2,959	2,811	2,425	2,520	2,572	28,819
Total liquefied refinery gases	9,106	7,971	8,395	7,858	8,930	9,346	10,106	10,708	9,446	9,292	8,913	9,262	109,333
Kerosine[2]	6,101	5,715	4,878	4,462	4,217	2,790	3,697	4,342	4,344	4,426	4,719	5,804	55,495
Distillate fuel oil[2]	88,418	75,005	78,480	74,595	75,366	77,216	80,282	80,346	84,358	85,083	83,004	86,283	968,436
Residual fuel oil	43,857	37,912	40,260	37,335	35,678	34,569	35,798	35,522	35,500	36,130	36,426	41,970	450,957

Petrochemical feedstocks:													
Still gas	1,313	1,145	1,077	1,155	1,070	1,298	1,379	1,430	1,309	1,482	1,704	1,361	15,723
Naphtha-400°	4,790	3,418	4,259	3,932	3,760	4,346	4,632	4,733	5,418	5,076	5,372	5,034	54,770
Other	4,661	3,011	4,139	3,177	3,344	3,912	4,611	5,144	4,811	4,811	4,730	5,343	51,695
Total petrochemical feedstocks	10,764	7,574	9,475	8,264	8,174	9,556	10,622	11,307	11,538	11,369	11,806	11,738	122,187
Special naphthas[2]	2,084	1,990	2,117	1,897	2,339	2,140	2,368	2,128	2,558	2,333	2,552	2,694	27,200
Lubricants:													
Bright stock	637	443	497	468	550	539	542	572	524	627	648	500	6,547
Neutral	2,274	1,468	2,205	1,983	1,995	2,211	2,296	2,152	2,508	2,518	2,417	2,487	26,514
Other grades	1,950	1,743	1,941	1,953	1,980	1,882	1,957	1,948	1,818	1,933	1,926	2,129	23,160
Total lubricants	4,861	3,654	4,643	4,404	4,525	4,632	4,795	4,672	4,850	5,078	4,991	5,116	56,221
Wax (280 pounds = 1 barrel):													
Microcrystalline	89	43	58	73	75	61	83	96	89	98	84	83	932
Crystalline-fully refined	152	102	124	158	188	181	234	233	198	252	270	246	2,338
Crystalline-other	217	135	133	193	173	198	213	200	200	258	265	210	2,395
Total wax	458	280	315	424	436	440	530	529	487	608	619	539	5,665
Coke (1 short ton = 5.0 barrels)	10,892	9,825	10,523	10,215	10,155	10,698	11,295	10,990	11,102	11,537	10,577	11,432	129,241
Asphalt (1 short ton = 5.5 barrels)	8,184	7,516	9,220	9,410	13,119	14,448	16,613	16,202	14,827	14,466	11,629	8,323	143,957
Road oil	414	229	263	264	407	884	615	552	881	297	401	287	4,944
Still gas for fuel	14,798	12,919	14,312	13,674	14,822	14,536	16,264	15,743	14,871	14,273	13,860	15,279	175,351
Miscellaneous products[2]	2,123	2,175	2,663	2,463	2,624	2,169	2,243	2,253	2,833	3,181	2,919	3,623	31,269
Processing gain(-) or loss (+)	-16,084	-12,272	-13,043	-11,434	-12,768	-12,970	-13,365	-13,812	-15,841	-15,905	-14,839	-15,449	-167,782
INPUT 1976[p]													
Crude petroleum:													
Domestic	251,367	245,176	255,030	242,648	252,337	250,450	254,959	257,710	240,410	236,200	247,044	255,798	2,989,129
Foreign	138,006	126,998	144,162	139,162	148,179	163,525	175,969	172,819	171,076	176,696	175,995	188,524	1,921,111
Total crude petroleum	389,373	372,174	,399,192	381,810	400,516	413,975	430,928	430,529	411,486	412,896	423,039	444,322	4,910,240
Unfinished oils rerun (net)	+1,774	+2,110	-3,434	+63	+2,300	-267	-861	+5,634	-1,256	+498	-1,002	+2,040	+7,599
Total crude and unfinished oils rerun	391,147	374,284	395,758	381,873	402,816	413,708	430,067	436,163	410,230	413,394	422,037	446,362	4,917,839
Natural gas liquids:													
Liquefied petroleum gases	9,368	8,104	7,593	6,468	6,555	6,838	6,838	6,907	7,783	8,233	8,851	11,722	95,260
Natural gasoline	9,962	10,252	10,141	11,588	11,104	11,667	12,110	11,881	11,137	11,383	9,997	11,098	132,320
Plant condensate	3,241	4,645	3,154	3,415	3,187	3,032	3,059	2,751	2,475	2,348	2,942	3,622	37,871
Total natural gas liquids	22,571	23,001	20,888	21,471	20,846	21,537	22,007	21,539	21,395	21,964	21,790	26,442	265,451
Other hydrocarbons and hydrogen	1,113	1,188	1,044	1,138	1,156	1,240	1,358	1,027	1,025	1,077	1,090	1,493	13,949

See footnotes at end of table.

Table 20.—Input and output at refineries in the United States, by month —Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
OUTPUT 1976[p]													
Gasoline:													
Motor gasoline[2]	200,958	187,708	200,114	196,864	210,010	219,087	222,401	221,614	206,352	207,019	208,132	222,452	2,502,711
Aviation gasoline	718	850	1,030	880	977	1,402	1,372	1,603	1,388	1,040	1,064	1,008	13,332
Total gasoline[2]	201,676	188,558	201,144	197,744	210,987	220,489	223,773	223,217	207,740	208,059	209,196	223,460	2,516,043
Jet fuel:													
Naphtha-type[2]	5,003	4,822	5,319	5,865	6,659	5,109	5,801	5,846	6,524	6,113	5,665	5,746	68,472
Kerosine-type	22,565	21,789	23,426	21,936	21,209	21,251	23,131	23,353	23,164	21,467	21,933	22,150	267,374
Total jet fuel[2]	27,568	26,611	28,745	27,801	27,868	26,360	28,932	29,199	29,688	27,580	27,598	27,896	335,846
Ethane (including ethylene)	338	456	534	466	517	486	425	516	580	487	416	418	5,639
Liquefied refinery gases:													
For fuel use	6,637	6,050	6,632	7,046	7,748	7,342	7,605	7,577	7,096	6,833	6,721	6,936	84,223
For chemical use	2,480	2,671	3,154	2,964	3,390	2,850	2,937	3,118	2,872	2,259	2,805	3,206	34,706
Total liquefied refinery gases	9,117	8,721	9,786	10,010	11,138	10,192	10,542	10,695	9,968	9,092	9,526	10,142	118,929
Kerosine[2]	5,559	5,410	5,009	3,908	3,512	3,511	3,333	4,286	4,452	4,782	4,912	6,917	55,591
Distillate fuel oil[2]	84,750	85,870	86,596	79,652	84,878	86,550	91,733	92,429	88,405	92,856	95,410	100,903	1,070,032
Residual fuel oil	43,876	40,414	40,628	38,486	38,958	37,226	39,251	40,941	39,912	41,885	47,431	54,945	503,953
Petrochemical feedstocks:													
Still gas	1,598	1,406	1,465	1,253	1,615	1,550	1,456	1,076	1,070	1,224	1,396	2,339	17,448
Naphtha-400°	6,041	6,326	6,708	6,311	6,757	6,409	7,191	6,722	7,341	6,695	6,809	6,783	80,093
Other	5,424	5,423	5,865	5,381	5,028	4,532	6,236	5,970	5,046	5,488	6,290	6,196	66,879
Total petrochemical feedstocks	13,063	13,155	14,038	12,945	13,400	12,491	14,883	13,768	13,457	13,407	14,495	15,318	164,420
Special naphthas[2]	2,510	2,357	2,709	2,674	2,583	2,834	2,798	2,974	2,700	2,992	2,629	2,858	32,618
Lubricants:													
Bright stock	462	517	370	470	611	468	582	638	641	490	631	836	6,716
Neutral	2,396	2,015	2,588	2,312	2,512	2,661	2,597	2,823	2,656	2,762	2,613	2,763	30,698
Other grades	1,522	1,720	1,901	2,337	2,237	2,217	2,106	2,036	2,140	2,275	2,144	1,754	24,389
Total lubricants	4,380	4,252	4,859	5,119	5,360	5,346	5,285	5,497	5,437	5,527	5,388	5,353	61,803

Wax (280 pounds = 1 barrel):													
Microcrystalline	82	67	60	76	77	66	87	82	76	75	72	74	894
Crystalline-fully refined	262	219	258	242	274	278	263	296	277	274	250	294	3,187
Crystalline-other	210	201	221	271	254	257	230	298	253	259	243	230	2,927
Total wax	554	487	539	589	605	601	580	676	606	608	565	598	7,008
Coke (1 short ton = 5.0 barrels)	11,003	10,179	10,884	10,506	11,110	10,743	11,203	11,594	10,698	10,675	10,495	11,055	130,145
Asphalt (1 short ton = 5.5 barrels)	6,843	6,948	8,639	10,191	12,604	14,865	15,968	15,705	15,190	13,147	11,061	8,545	139,706
Road oil	47	115	129	417	217	405	560	532	333	176	81	228	3,240
Still gas for fuel	14,770	14,336	14,723	14,397	14,846	15,815	16,296	16,192	14,939	14,180	14,884	15,288	180,666
Miscellanous products[2]	3,471	4,772	4,059	3,251	3,212	2,944	3,120	3,296	3,626	3,893	4,791	5,840	46,275
Processing gain (-) or loss (+)	-14,694	-14,168	-15,331	-13,674	-16,977	-14,373	-15,250	-12,788	-15,081	-12,911	-13,961	-15,467	-174,675

[p]Preliminary.
[1]Includes some Athabasca hydrocarbons.
[2]Production at gas-processing plants shown as direct transfer and omitted from the input and output at refineries.

Table 21.—Input and output at refineries

(Thousand

Item	District I			District II				
	East coast	Appalachian No.1	Total	Appalachian No.2	Ind., Ill., etc.	Minn., Wisc., etc.	Okla., Kans., etc.	Total
Input 1975								
Crude petroleum:								
Domestic	31,968	28,677	60,645	8,304	600,205	23,065	331,051	962,625
Foreign[1]	424,287	28,871	453,158	12,593	195,369	63,932	11,033	282,927
Total crude petroleum	456,255	57,548	513,803	20,897	795,574	86,997	342,084	1,245,552
Unfinished oils rerun (net)	19,055	295	19,350	474	-1,754	-48	-341	-1,699
Total crude and unfinished oils rerun	475,310	57,843	533,153	21,371	793,820	86,949	341,743	1,243,883
Natural gas liquids:								
Liquefied petroleum gases	93	71	164	793	17,318	3,182	12,240	33,533
Natural gasoline	214	--	214	--	4,922	3,085	11,896	19,903
Plant condensate	131	2,909	3,040	--	7,844	2,611	560	11,015
Total natural gas liquids	438	2,980	3,418	793	30,084	8,878	24,696	64,451
Other hydrocarbons and hydrogen	994	--	994	--	766	14	212	992
Output 1975								
Gasoline:								
Motor gasoline[2]	225,079	22,943	248,022	12,506	459,883	52,260	207,435	732,084
Aviation gasoline	110	6	116	--	1,460	--	366	1,826
Total gasoline[2]	225,189	22,949	248,138	12,506	461,343	52,260	207,801	733,910
Jet fuel:								
Naphtha-type	1,922	522	2,444	--	6,762	1,257	6,064	14,083
Kerosine-type	13,099	527	13,626	--	36,639	1,804	9,263	47,706
Total jet fuel	15,021	1,049	16,070	--	43,401	3,061	15,327	61,789
Ethane (including ethylene)	40	--	40	--	--	--	352	352
Liquefied gases:								
For fuel use	10,396	964	11,360	377	15,190	1,977	6,034	23,578
For chemical use	3,992	44	4,036	--	2,960	--	635	3,595
Total liquefied gases	14,388	1,008	15,396	377	18,150	1,977	6,669	27,173
Kerosine[2]	3,501	1,638	5,139	626	11,810	234	1,035	13,705
Distillate fuel oil[2]	105,603	15,361	120,964	5,242	168,313	22,906	88,376	284,837
Residual fuel oil	61,962	6,272	68,234	1,700	50,723	6,852	10,415	69,690
Petrochemical feedstocks:								
Still gas	586	174	760	--	1,302	59	--	1,361
Naphtha-400°	5,602	--	5,602	--	2,865	--	663	3,528
Other	207	229	436	--	1,694	--	141	1,835
Total petrochemical feedstock	6,395	403	6,798	--	5,861	59	804	6,724
Special naphthas[2]	163	142	305	150	3,689	--	2,170	6,009
Lubricants:								
Bright stock	582	1,414	1,996	--	171	--	508	679
Neutral	2,092	2,654	4,746	--	2,193	--	2,583	4,776
Other grades	2,701	283	2,984	--	1,293	--	1,639	2,932
Total lube oil	5,375	4,351	9,726	--	3,657	--	4,730	8,387
Wax (280 pounds=1barrel):								
Microcrystalline	39	137	176	--	--	--	193	193
Crystalline-fully refined	304	26	330	--	209	--	200	409
Crystalline-other	--	397	397	--	99	--	592	691
Total wax	343	560	903	--	308	--	985	1,293
Coke (1 short ton=5.0 barrels)	13,306	257	13,563	253	23,996	3,059	11,606	38,914
Asphalt (1 short ton=5.5 barrels)	26,695	1,886	28,581	1,401	29,864	5,120	13,619	50,004
Road oil	--	--	--	--	2,432	83	509	3,024
Still gas for fuel	18,623	1,674	20,197	441	32,039	2,594	12,344	47,418
Miscellaneous	2,177	3,538	5,715	47	5,039	106	984	6,176
Processing gain (-) or loss (+)	-22,039	-265	-22,304	-579	-35,965	-2,470	-11,075	-50,079

See footnotes at end of table.

in the United States, by PAD district

barrels)

District III						District IV	Distric V	
Texas inland	Texas gulf	La. gulf	Ark., La. inland, etc.	N. Mex.	Total	(Other Rocky Mt.)	(West coast)	United States
152,375	752,994	498,068	55,903	29,039	1,488,379	139,003	396,362	3,047,014
5,258	299,739	125,781	671	--	431,449	16,392	310,486	1,494,412
157,633	1,052,733	623,849	56,574	29,039	1,919,328	155,395	706,848	4,541,426
2,474	-21,501	12,317	330	-2,753	-9,133	3,181	935	12,664
160,107	1,031,232	636,166	56,904	26,286	1,910,695	158,576	707,783	4,554,090
6,134	14,720	22,514	1,092	523	44,983	3,635	7,347	89,662
15,397	71,170	16,055	2,159	841	105,622	2,132	6,216	134,087
100	6,644	1,000	3,519	115	11,378	7,403	2,734	35,570
21,631	92,534	39,569	6,770	1,479	161,983	13,170	16,297	259,319
220	2,525	4,328	509	13	7,595	366	3,832	13,779
93,422	528,867	331,607	23,148	9,909	986,953	83,766	328,135	2,378,960
2,047	4,054	1,926	--	--	8,027	429	3,320	13,718
95,469	532,921	333,533	23,148	9,909	994,980	84,195	331,455	2,392,678
6,023	8,647	7,338	1,618	2,257	25,883	4,267	18,943	65,620
7,371	53,024	59,374	1	37	119,807	4,730	66,492	252,361
13,394	61,671	77,712	1,619	2,294	145,690	8,997	85,435	317,981
80	2,609	634	--	--	3,323	--	340	4,055
3,224	13,701	12,263	1,040	555	30,783	1,935	12,858	80,514
345	15,108	2,678	154	51	18,336	141	2,711	28,819
3,569	28,809	14,941	1,194	606	49,119	2,076	15,579	109,333
1,102	21,219	8,227	632	1,475	32,655	1,016	2,980	55,495
31,690	239,224	142,120	12,145	6,749	431,928	46,382	84,325	968,436
11,597	90,259	46,508	10,744	4,851	163,959	13,030	136,044	450,957
293	10,987	759	--	54	12,093	935	574	15,723
5,434	34,630	1,582	271	--	41,917	--	3,723	54,770
3,228	23,249	21,635	233	--	48,345	--	1,078	51,694
8,955	68,866	23,976	504	54	102,355	935	5,375	122,187
994	14,210	134	1,730	--	17,068	65	3,753	27,200
--	2,040	498	--	--	2,538	35	1,299	6,547
--	8,529	5,131	719	--	14,379	281	2,332	26,514
--	13,953	766	1,169	--	15,888	19	1,337	23,160
--	24,522	6,395	1,888	--	32,805	335	4,968	56,221
48	127	33	355	--	563	--	--	932
--	557	638	--	--	1,195	41	363	2,338
--	951	52	--	--	1,003	--	304	2,395
48	1,635	723	355	--	2,761	41	667	5,665
3,387	23,365	13,445	703	200	41,100	3,639	32,025	129,241
6,659	7,439	11,083	8,124	931	34,236	9,759	21,377	143,957
22	443	--	--	--	465	413	1,042	4,944
5,795	34,024	29,555	1,496	677	71,547	4,931	31,158	175,351
1,359	8,387	7,309	418	--	17,473	35	1,870	31,269
-2,162	-33,312	-25,232	-517	32	-61,191	-3,737	-30,471	-167,782

Table 21.—Input and output at refineries

(Thousand

Item	District I			District II				
	East coast	Appa-lachian No.1	Total	Appa-lachian No.2	Ind., Ill., etc.	Minn., Wisc., etc.	Okla., Kans., etc.	Total
Input 1976[p]								
Crude petroleum:								
Domestic	22,502	39,665	62,167	6,926	580,133	42,748	325,801	955,608
Foreign[1]	495,544	22,518	518,062	15,824	256,455	51,264	38,444	361,987
Total crude petroleum	518,046	62,183	580,229	22,750	836,588	94,012	364,245	1,317,595
Unfinished oils rerun (net)	+16,468	+188	+16,656	-188	-344	+7	+1,039	+514
Total crude and unfinished oils rerun	534,514	62,371	596,885	22,562	836,244	94,019	365,284	1,318,109
Natural gas liquids:								
Liquefied petroleum gases	21	175	196	1,402	18,463	3,441	13,220	36,526
Natural gasoline	--	11	11	--	4,856	1,117	12,009	17,982
Plant condensate	--	2,313	2,313	151	13,072	1,792	240	15,255
Total natural gas liquids	21	2,499	2,520	1,553	36,391	6,350	25,469	69,763
Other hydrocarbons	1,015	--	1,015	--	428	--	284	712
Output 1976[p]								
Gasoline:								
Motor gasoline[2]	252,506	25,550	278,056	14,337	475,917	49,990	220,791	761,035
Aviation gasoline	161	--	161	--	1,342	--	447	1,789
Total gasoline[2]	252,667	25,550	278,217	14,337	477,259	49,990	221,238	762,824
Jet fuel:								
Naphtha-type	3,181	541	3,722	--	6,511	1,095	6,255	13,861
Kerosine-type	14,636	913	15,549	--	36,165	2,078	8,572	46,815
Total jet fuel	17,817	1,454	19,271	--	42,676	3,173	14,827	60,676
Ethane (including ethylene)	27	--	27	--	--	--	464	464
Liquefied gases:								
For fuel use	12,532	1,556	14,088	--	16,352	2,341	7,120	25,813
For chemical use	5,570	--	5,570	400	2,795	--	648	3,843
Total liquefied gases	18,102	1,556	19,658	400	19,147	2,341	7,768	29,656
Kerosine[2]	3,335	1,642	4,977	800	11,425	255	765	13,245
Distillate fuel oil[2]	129,005	16,015	145,020	5,434	182,154	25,540	96,758	309,886
Residual fuel oil	61,669	5,977	67,646	1,704	61,698	6,202	15,650	85,254
Petrochemical feedstocks:								
Still gas	758	38	796	--	2,915	--	--	2,915
Naphtha-400°	7,021	--	7,021	--	4,408	44	998	5,450
Other	152	--	152	--	2,337	--	268	2,605
Total petrochemical feedstock	7,931	38	7,969	--	9,660	44	1,266	10,970
Special naphthas[2]	99	264	363	128	3,774	--	2,802	6,704
Lubricants:								
Bright stock	790	1,502	2,292	--	296	--	661	957
Neutral	2,448	2,860	5,308	--	2,648	--	2,976	5,624
Other grades	3,005	268	3,273	--	1,411	--	1,661	3,072
Total lube oil	6,243	4,630	10,873	--	4,355	--	5,298	9,653
Wax (280 pounds=1barrel):								
Microcrystalline	31	157	188	--	--	--	78	78
Crystalline-fully refined	241	31	272	--	167	--	283	450
Crystalline-other	119	440	559	--	87	--	707	794
Total wax	391	628	1,019	--	254	--	1,068	1,322
Coke (1 short ton=5.0 barrels)	13,638	423	14,061	268	24,325	3,276	10,587	38,456
Asphalt (1 short ton=5.5 barrels)	27,729	1,519	29,248	1,368	30,275	6,784	13,178	51,605
Road oil	--	--	--	--	1,900	--	335	2,235
Still gas for fuel	19,285	1,929	21,214	179	30,281	1,458	13,964	45,882
Miscellaneous products[2]	2,344	3,887	6,231	28	15,158	134	1,145	16,465
Processing gain (-) or loss (+)	-24,732	-642	-25,374	-531	-41,278	+1,172	-16,076	-56,713

[p]Preliminary.
[1]Includes Athabasca hydrocarbons.
[2]Production at gas processing plants shown as direct transfers and omitted from input and output at refineries.

in the United States, by PAD district —Continued

barrels)

District III						District IV	Distric V	
Texas inland	Texas gulf	La. gulf	Ark., La. inland, etc.	N. Mex.	Total	(Other Rocky Mt.)	(West coast)	United States
158,809	692,710	506,082	61,020	29,724	1,448,345	142,955	380,054	2,989,129
10,148	442,785	190,500	731	--	644,164	18,629	378,269	1,921,111
168,957	1,135,495	696,582	61,751	29,724	2,092,509	161,584	758,323	4,910,240
+4,415	-22,576	+6,144	-95	-2,960	-15,072	+2,753	+2,748	+7,599
173,372	1,112,919	702,726	61,656	26,764	2,077,437	164,337	761,071	4,917,839
6,682	17,399	21,696	1,095	531	47,403	4,200	6,935	95,260
15,308	75,074	13,668	1,630	1,022	106,702	1,645	5,980	132,320
98	5,772	1,366	4,222	71	11,529	6,056	2,718	37,871
22,088	98,245	36,730	6,947	1,624	175,734	11,901	15,633	265,451
135	2,983	5,084	487	--	8,609	151	3,462	13,949
101,170	541,251	349,999	25,388	9,650	1,027,458	86,074	350,088	2,502,711
1,806	4,046	1,992	--	--	7,844	506	3,032	13,332
102,976	545,297	351,991	25,388	9,650	1,035,302	86,580	353,120	2,516,043
6,890	9,339	7,324	1,553	2,482	27,588	4,328	18,973	68,472
7,563	57,641	64,046	144	165	129,559	5,410	70,041	267,374
14,453	66,980	71,370	1,697	2,647	157,147	9,738	89,014	335,846
215	3,457	941	--	--	4,643	--	505	5,639
2,961	12,400	12,940	859	357	29,525	2,088	12,709	84,223
620	17,053	4,021	205	171	22,070	78	3,145	34,706
3,589	29,453	16,961	1,064	528	51,595	2,166	15,854	118,929
649	21,803	9,054	570	1,468	33,534	601	3,234	55,591
38,407	259,082	156,138	14,997	6,830	475,454	47,395	92,277	1,070,032
9,264	104,746	57,650	9,210	5,440	186,310	14,436	150,307	503,953
254	10,381	935	169	--	11,739	1,014	984	17,448
5,086	52,539	7,708	11	--	65,344	--	2,278	80,093
3,137	29,475	28,757	262	--	61,631	--	2,491	66,879
8,477	92,395	37,400	442	--	138,714	1,014	5,753	164,420
1,611	17,246	1,155	2,257	--	22,269	107	3,175	32,618
--	2,444	451	--	--	2,895	45	527	6,716
--	9,308	6,009	809	--	16,126	318	3,322	30,698
78	14,289	931	1,123	--	16,421	22	1,601	24,389
78	26,041	7,391	1,932	--	35,442	385	5,450	61,803
73	171	31	353	--	628	--	--	894
--	749	1,044	--	--	1,793	98	574	3,187
--	1,078	48	--	--	1,126	--	448	2,927
73	1,998	1,123	353	--	3,547	98	1,022	7,008
3,104	22,833	14,683	699	194	41,513	29,03	33,212	130,145
6,096	6,391	6,705	8,853	830	38,875	9,645	20,333	139,706
1	197	--	12	--	210	429	366	3,240
6,100	39,105	25,953	1,721	546	73,425	4,474	35,671	180,666
960	9,795	9,715	391	--	20,861	86	2,632	46,275
-458	-32,752	-23,720	-486	+255	-57,161	-3,668	-31,759	-174,675

Table 22.—Salient statistics of the major refined petroleum products in the United States

(Thousand barrels)

Product	1973	1974	1975	1976[p]
Isopentane:				
Production	5,828	3,794	3,759	3,470
Stocks at plants	32	16	6	5
Used at refineries	5,895	3,810	3,769	3,471
Natural gasoline:				
Production	155,880	144,129	130,065	129,282
Stocks, end of year:				
At plants	5,043	5,202	4,897	5,026
At refineries	1,085	1,262	1,314	1,618
Total stocks	6,128	6,464	6,211	6,644
Used at refineries	154,455	143,793	130,318	128,849
Plant condensate:				
Production	19,838	17,733	15,626	14,700
Stocks, end of year:				
At plants	739	507	617	413
At refineries	936	563	548	1,066
Total stocks	1,675	1,070	1,165	1,479
Imports	39,344	32,364	26,972	24,408
Used at refineries	56,911	44,596	35,570	37,871
Domestic demand	1,869	6,106	6,933	923
Finished gasoline:				
Production:				
At refineries	2,398,831	2,336,383	2,392,678	2,516,043
At gas-processing plants	3,029	1,084	959	946
Total gasoline production	2,401,860	2,337,467	2,393,637	2,516,989
Stocks, end of year:				
At refineries	213,334	221,817	237,949	234,227
At plants	83	64	53	45
Total stocks	213,417	221,881	238,002	234,272
Imports	48,759	74,402	67,249	47,774
Exports	1,664	1,013	850	1,297
Domestic demand	2,452,687	2,402,392	2,450,296	2,567,196
Motor gasoline:				
Production:				
At refineries	2,382,418	2,320,488	2,378,960	2,502,711
At gas-processing plants	3,029	1,084	959	946
Total motor gasoline production	2,385,447	2,321,572	2,379,919	2,503,657
Stocks, end of year:				
At refineries	209,395	218,346	234,925	231,387
At gas-processing plants	83	64	53	45
Total motor gasoline stocks	209,478	218,410	234,978	231,432
Imports	48,759	74,402	67,249	47,774
Exports	1,466	865	744	1,143
Domestic demand	2,436,156	2,386,177	2,436,229	2,553,834
Aviation gasoline:				
Production	16,413	15,895	13,718	13,332
Stocks, end of year	3,939	3,471	3,024	2,840
Exports	198	148	106	154
Domestic demand	16,531	16,215	14,067	13,362
Jet fuel:				
Production	313,689	305,064	317,981	335,846
Stocks, end of year	28,544	29,435	30,380	32,085
Imports	77,557	59,396	48,523	27,983
Exports	1,568	969	610	766
Domestic demand	386,627	362,600	365,290	361,358
Naphtha-type:				
Production at refineries	65,997	71,175	65,620	68,472
Stocks at refineries, end of year	5,599	5,529	5,222	6,495
Imports	13,315	10,006	10,339	5,514
Exports	640	80	--	--
Domestic demand	79,220	81,171	76,543	72,713
Kerosine-type:				
Production	247,692	233,889	252,361	267,374
Stocks, end of year	22,945	23,906	25,158	25,590
Imports	64,242	49,390	38,184	22,469
Exports	928	889	610	766
Domestic demand	307,407	281,429	288,747	288,645

See footnotes at end of table.

Table 22.—Salient statistics of the major refined petroleum products in the United States —Continued

(Thousand barrels)

Product	1973	1974	1975	1976[P]
Ethane (including ethylene):				
Production:				
At gas-processing plants	108,220	117,791	122,945	133,654
At refineries	9,194	6,330	4,055	5,639
Total production	117,414	124,121	127,000	139,293
Stocks at plants, end of year	5,023	4,562	[1]7,014	[1]13,600
Domestic demand:				
Plant ethane	110,249	118,252	120,493	127,068
Refinery ethane and/or ethylene	9,194	6,330	4,055	5,639
Total domestic demand	119,443	124,582	124,548	132,707
Liquefied gases:				
Production:				
At gas-processing plants (LPG)	338,813	330,155	321,141	303,712
At refineries (LRG):				
For fuel use	89,570	81,561	80,514	84,223
For chemical use	38,062	35,433	28,819	34,706
Total production at refineries	127,632	116,994	109,333	118,929
Total production	466,445	447,149	430,474	422,641
Stocks, end of year:				
LPG stocks:				
At plants	83,086	97,956	105,557	93,117
At refineries	2,813	4,093	4,202	2,389
Total LPG stocks	85,899	102,049	109,759	95,506
LRG Stocks:				
For fuel use	7,403	5,757	8,112	6,940
For chemical use	316	174	263	249
Total LRG stocks	7,719	5,931	8,375	7,189
Total stocks	93,618	107,980	[1]118,134	[1]102,695
Imports	48,002	44,971	40,727	47,436
Exports	9,955	9,038	9,488	8,993
LPG used at refineries	80,221	80,217	89,662	95,260
Domestic demand:				
LPG for fuel and chemical use	281,624	269,721	255,008	261,148
LRG for fuel use	89,654	83,207	78,159	85,395
LRG for chemical use	38,040	35,575	28,730	34,720
Total domestic demand	409,318	388,503	361,897	381,263
Propane (including propylene):				
Production:				
At gas-processing plants	212,886	206,539	200,573	189,614
At refineries:				
For fuel use	73,531	62,298	63,385	65,055
For chemical use	25,329	25,155	21,876	25,646
Total production at refineries	98,860	87,453	85,261	90,701
Total production	311,746	293,992	285,834	280,315
Stocks, end of year:				
Plant propane stocks:				
At plants	59,704	64,713	76,024	69,442
At refineries	357	97	92	295
Total plant propane stocks	60,061	64,810	76,116	69,737
Refinery propane and/or propylene stocks:				
For fuel use	4,399	3,684	5,527	3,851
For chemical use	187	112	200	216
Total refinery propane and/or propylene stocks	4,586	3,796	5,727	4,067
Total stocks	64,647	68,606	81,843	73,804

See footnotes at end of table.

Table 22.—Salient statistics of the major refined petroleum products in the United States —Continued

(Thousand barrels)

Product	1973	1974	1975	1976[P]
Liquefied gases: —Continued				
Propane (including propylene): —Continued				
Imports	25,791	21,464	22,058	24,768
Exports	5,500	4,971	4,852	4,766
Plant propane used at refineries	2,755	3,465	3,926	4,510
Domestic demand:				
Plant propane	218,770	214,818	202,547	211,485
Refinery propane and/or propylene:				
For fuel use	74,091	63,013	61,542	66,731
For chemical use	25,335	25,230	21,788	25,630
Total refinery propane and/or propylene domestic demand	99,426	88,243	83,330	92,361
Total domestic demand	318,196	303,061	285,877	303,846
Butane (including butylene):				
Production:				
At gas-processing plants	88,766	87,171	85,018	81,370
At refineries:				
For fuel use	13,036	13,598	12,751	14,411
For chemical use	6,666	6,442	4,673	5,630
Total production at refineries	19,702	20,040	17,424	20,041
Total production	108,468	107,211	102,442	101,411
Stocks, end of year:				
Plant butane stocks:				
At plants	15,289	20,992	20,998	16,450
At refineries	1,369	2,212	2,325	923
Total refinery butane and/or butylene stocks	2,487	2,053	2,567	2,930
Total stocks	19,145	25,257	25,890	20,303
Exports	4,455	4,067	4,636	4,227
Imports	22,211	23,507	18,669	22,668
Plant butane used at refineries	39,327	45,599	48,576	56,721
Domestic demand:				
Plant butane	62,351	54,466	50,356	49,040
Refinery butane and/or butylene:				
For fuel use	12,726	14,055	12,245	14,014
For chemical use	6,665	6,419	4,665	5,664
Total refinery butane and/or butylene	19,391	20,474	16,910	19,678
Total domestic demand	81,742	74,940	67,266	68,718
Butane-propane mixture:				
Production:				
At gas-processing plants	3,509	3,027	2,673	2,557
At refineries:				
For fuel use	3,003	5,665	4,378	4,757
For chemical use	3,491	655	51	790
Total production at refineries	6,494	6,320	4,429	5,547
Total production	10,003	9,347	7,102	8,104
Stocks, end of year:				
Plant butane-propane mixture:				
At plants	826	1,565	872	918
At refineries	128	26	14	13
Total plant butane-propane mixture stocks	954	1591	886	931

See footnotes at end of table.

Table 22.—Salient statistics of the major refined petroleum products in the United States —Continued

(Thousand barrels)

Product	1973	1974	1975	1976[p]
Liquefied gases: —Continued				
Butane-propane mixture: —Continued				
Stocks, end of year: —Continued				
Refinery butane-propane mixture:				
For fuel use	533	59	65	172
For chemical use	3	1	--	2
Total refinery butane-propane mixture stocks	536	60	65	174
Total stocks	1,490	1,651	951	1,105
Plant butane-propane mixture used at refineries	3,027	1,953	1,273	1,889
Domestic demand:				
Plant butane-propane mixture	503	437	2,105	623
Refinery butane-propane mixture:				
For fuel use	2,837	6,139	4,372	4,650
For chemical use	3,490	657	52	788
Total refinery butane-propane mixture	6,327	6,796	4,424	5,438
Total domestic demand	6,830	7,233	6,529	6,061
Isobutane:				
Production:				
At gas-processing plants	33,652	33,418	32,877	30,171
At refineries	2,576	3,181	2,219	2,640
Total production	36,228	36,599	35,096	32,811
Stocks, end of year:				
Plant isobutane:				
At plants	7,267	10,686	7,663	6,307
At refineries	959	1,758	1,771	1,158
Total plant isobutane stocks	8,226	12,444	9,434	7,465
Refinery isobutane	110	22	16	18
Total stocks	8,336	12,466	9,450	7,483
Plant isobutane used at refineries	35,112	29,200	35,887	32,140
Domestic demand: Refinery isobutane for chemical use	2,550	3,269	2,225	2,638
Kerosine (including range oil):				
Production:				
At refineries	79,422	56,646	55,495	55,591
At gas-processing plants	704	245	178	149
Total production	80,126	56,891	55,673	55,740
Stocks, end of year:				
At refineries	20,985	15,252	15,556	12,507
At gas-processing plants	37	17	15	7
Total stocks	21,022	15,269	15,571	12,514
Imports	785	1,744	1,073	3,163
Exports	85	36	52	40
Domestic demand	78,915	64,352	57,990	61,920
Distillate fuel oil:				
Production:				
At refineries	1,029,343	973,764	968,436	1,070,032
At gas-processing plants	835	261	214	177
Total production	1,030,178	974,025	968,650	1,070,209
Crude used directly as distillate	760	774	587	540
Stocks, end of year:				
At refineries	[2]196,421	[2]200,029	[2]208,787	185,948
At plants	40	39	46	38
Total stocks	196,461	200,068	208,833	185,986

See footnotes at end of table.

Table 22.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1973	1974	1975	1976[p]
Distillate fuel oil:—Continued				
Imports	143,149	105,579	56,678	52,470
Exports	3,231	855	267	421
Domestic demand	1,128,714	1,075,916	1,040,571	1,145,645
Residual fuel oil:				
Production	354,597	390,491	450,957	503,953
Crude used directly as residual	6,126	4,751	5,616	6,298
Stocks, end of year	53,480	59,694	74,126	72,344
Imports	[3]676,225	[3]579,157	[3]446,528	[3]511,765
Exports	8,507	4,969	5,342	4,210
Domestic demand	1,030,177	963,216	898,572	1,019,588
Petrochemical feedstocks (excluding LRG):[4]				
Production	132,564	134,764	122,187	164,420
Stocks, end of year	2,387	3,486	2,924	4,714
Imports	3,825	4,364	2,061	1,370
Exports	6,839	5,561	8,037	11,144
Domestic demand:				
Still gas	12,428	14,375	15,723	17,448
Naphtha-400°	56,822	61,879	53,512	73,297
Other	60,679	56,214	47,538	62,111
Total domestic demand	129,929	132,468	116,773	152,856
Special naphthas:				
Production:				
At refineries	32,873	33,362	27,200	32,618
At gas-processing plants	210	175	125	20
Total production	33,083	33,537	27,325	32,638
Stocks, end of year:				
At refineries	4,514	5,716	4,373	4,441
At plants	7	4	4	--
Total stocks	4,521	5,720	4,377	4,441
Imports	88	938	43	45
Exports	1,652	1,300	1,221	2,510
Domestic demand	32,230	31,976	27,490	30,109
Lubricants:				
Production	68,742	70,694	56,221	61,803
Stocks, end of year	12,186	16,060	14,337	12,274
Imports	2,091	1,786	1,335	1,361
Exports:				
Grease	251	277	265	261
Oil	12,496	11,659	8,846	9,234
Total exports	12,747	11,936	9,111	9,495
Domestic demand	59,171	56,670	50,169	55,732
Wax (1 barrel = 280 pounds):				
Production	6,768	6,929	5,665	7,008
Stocks, end of year	990	1,195	861	686
Imports	1,067	956	684	652
Exports	965	879	607	625
Domestic demand	6,941	6,801	6,076	7,210
Coke (5 barrels = 1 short ton):				
Production:				
Marketable coke	67,527	63,950	66,500	67,908
Catalyst coke	64,763	59,796	62,741	62,237
Total production	132,290	123,746	129,241	130,145
Stocks, end of year	9,974	5,420	7,360	10,636
Exports	34,976	41,244	37,253	37,778
Domestic demand	95,156	87,056	90,048	89,091
Asphalt (5.5 barrels = 1 short ton):				
Production	167,884	164,237	143,957	139,706
Stocks, end of year	15,024	21,370	22,794	19,375
Imports	8,444	11,252	4,956	3,905
Exports	340	410	320	267
Domestic demand	182,602	168,733	147,384	146,763
Road oil:				
Production	7,326	7,162	4,944	3,240
Stocks, end of year	799	1,080	571	164
Domestic demand	7,832	6,881	5,453	3,647

See footnotes at end of table.

Table 22.—Salient statistics of the major refined petroleum products in the United States —Continued

(Thousand barrels)

Product	1973	1974	1975	1976[p]
Still gas for fuel:				
Production	176,758	175,724	175,351	180,666
Miscellaneous products:				
Production:				
At refineries	18,795	24,515	31,269	46,275
At gas-processing plants	1,066	731	946	935
Total production	19,861	25,246	32,215	47,210
Stocks, end of year:				
At refineries	1,378	1,815	2,578	1,932
At plants	16	10	5	5
Total stocks	1,394	1,825	2,583	1,937
Imports	--	655	2,340	720
Exports	1,187	1,207	1,124	1,112
Domestic demand	18,934	24,263	32,674	47,464
Unfinished oils (net):				
Input (+) Output (-)	+45,768	+37,351	+12,664	+7,599
Stocks, end of year	99,154	106,031	106,352	110,488
Imports	50,161	44,228	12,985	11,735

[p]Preliminary.

[1]Includes underground stocks at plants and refineries in thousand barrels. At plants: Ethane, 1975, 5,549; 1976, 11,180; propane, 1975, 68,765; 1976, 50,560; butane, 1975, 17,778; 1976, 12,100; butane-propane mixture, 1975, 162; 1976, 159; and isobutane, 1975, 6,891; 1976, 5,054. At refineries, (includes LRG): Propane, 1975, 4,822; 1976, 3,014; butane, 1975, 2,417; 1976, 2,260; butane-propane mixtures, 1975, 1; 1976, less than 1; and isobutane, 1975, 628; 1976, 103.

[2]Includes No.4 fuel oil, in thousand barrels: 1973, 3,499; 1974, 4,116; 1975, 5,035; 1976, 4,821.

[3]Includes foreign crude oil to be burned as fuel, in thousand barrels: 1973, 19,105; 1974, 7,508; 1975, 13,559; 1976, 5,553.

[4]Produced at petroleum refineries. Data for LRG petrochemical feedstocks are included with those for "Liquefied gases."

Note: "Stocks at refineries" include stocks at refineries and bulk terminals operated by refining and products pipeline companies including pipeline fill, and stocks at independent bulk terminals. "Stocks at plants" include stocks at plants and terminals operated by natural gas processing companies and natural gas liquids stocks at terminals of pipeline companies, including pipeline fill.

Table 23.—Production (refinery output) and consumption of motor gasoline in the United States, by State

(Thousand barrels)

State	1974		1975		1976[p]	
	Production	Consumption[1]	Production	Consumption[1]	Production	Consumption[1]
Alabama	528	44,349	736	45,672	1,725	48,307
Alaska	(2)	3,883	(2)	4,613	(2)	5,099
Arizona	--	27,328	1	28,380	3	29,784
Arkansas	7,443	27,433	7,156	28,230	7,440	29,928
California	[2]262,402	235,428	[2]265,086	243,256	[2]282,571	255,897
Colorado	8,420	30,999	9,324	32,350	9,669	33,635
Connecticut	--	31,602	--	32,180	--	33,171
Delaware	(3)	7,059	(3)	7,209	(3)	7,512
District of Columbia	--	5,725	--	5,805	--	5,600
Florida	--	100,124	--	103,467	--	107,322
Georgia	(3)	65,229	--	66,030	(3)	69,371
Hawaii	(2)	6,615	(2)	6,899	(2)	7,234
Idaho	--	10,900	--	11,487	--	12,396
Illinois	214,648	119,637	214,872	121,127	220,317	127,483
Indiana	80,022	65,216	79,000	65,781	84,869	66,292
Iowa	--	39,215	--	39,451	--	42,541
Kansas	[4]100,222	31,646	[4]106,302	32,852	[4]109,143	34,971
Kentucky	[5]29,197	39,919	[5]34,623	41,513	[5]35,550	43,821
Louisiana	280,733	41,818	296,641	43,894	310,211	47,415
Maine	--	12,382	--	12,762	--	13,510
Maryland	--	42,606	--	43,926	--	45,580
Massachusetts	--	54,689	--	55,083	--	57,114
Michigan	19,543	108,694	19,404	110,244	21,230	116,331
Minnesota	34,959	48,431	38,381	49,180	34,567	51,215
Mississippi	48,746	28,461	50,222	28,299	56,011	29,661
Missouri	(4)	62,586	(4)	63,541	(4)	66,717
Montana	27,069	10,667	27,048	10,829	28,189	11,902
Nebraska	(4)	20,674	(4)	20,975	(4)	22,378
Nevada	(2)	9,110	(2)	9,750	(2)	10,334
New Hampshire	--	9,299	--	9,603	--	10,138
New Jersey	89,760	75,588	85,321	78,132	91,136	80,891
New Mexico	9,820	16,275	9,909	16,868	9,650	18,116
New York	14,749	142,806	13,458	142,504	15,482	147,630
North Carolina	(6)	67,150	(6)	68,206	(6)	71,735
North Dakota	[7]13,678	9,793	[7]13,879	10,317	[7]15,423	10,779
Ohio	117,540	119,193	124,490	121,315	128,288	125,571
Oklahoma	99,516	39,893	101,133	41,505	111,648	43,625
Oregon	--	28,278	--	29,158	--	30,897
Pennsylvania	[3]138,363	114,616	[3]136,996	109,489	[3]160,689	119,191
Rhode Island	--	8,851	--	9,240	--	8,982
South Carolina	--	34,682	--	35,862	--	38,084
South Dakota	--	10,868	--	11,915	--	11,278
Tennessee	(5)	51,948	(5)	54,632	(5)	57,344
Texas	603,365	169,030	622,289	177,697	642,421	190,661
Utah	21,031	14,677	22,335	15,403	23,472	16,191
Vermont	--	5,603	--	5,720	--	6,074
Virgina	[6]13,170	58,130	[6]12,247	59,803	[6]10,749	63,392
Washington	60,086	39,689	63,048	41,239	67,514	44,099
West Virginia	(6)	18,248	(6)	19,346	(6)	20,727
Wisconsin	(7)	51,084	(7)	52,319	(7)	54,740
Wyoming	25,478	7,011	25,059	7,596	24,744	8,172
Total	2,320,488	2,425,137	2,378,960	2,482,654	2,502,711	2,610,838

[p]Preliminary.
[1]Source: Federal Highway Administration.
[2]Alaska, Hawaii, and Nevada included with California.
[3]Delaware and Georgia included with Pennsylvania.
[4]Nebraska and Missouri included with Kansas.
[5]Tennessee included with Kentucky.
[6]North Carolina and West Virginia included with Virginia.
[7]Wisconsin included with North Dakota.

Table 24.—Salient statistics of motor gasoline in the United States, by month and refining district

(Thousand barrels)

	1975						1976[P]					
	Production at refineries	Production at gas-processing plants	Imports	Exports	Total stocks, end of period[1]	Domestic demand	Production at refineries	Production at gas-processing plants	Imports	Exports	Total stocks, end of period[1]	Domestic demand
Month:												
January	201,768	73	8,115	17	242,340	192,382	200,958	77	2,850	6	240,510	198,347
February	175,727	80	4,784	266	251,974	170,691	187,708	76	2,427	179	248,901	181,641
March	188,167	86	4,645	26	248,749	196,097	200,114	80	3,806	199	239,097	213,605
April	181,377	84	3,989	38	232,619	201,542	196,864	74	2,980	225	224,008	214,782
May	189,918	86	4,398	14	213,997	213,010	210,010	77	3,461	35	225,079	212,442
June	200,082	79	5,304	22	207,155	212,285	219,087	83	5,631	14	225,408	224,458
July	217,088	83	6,475	39	212,504	218,258	222,401	82	5,883	41	226,961	226,772
August	213,024	70	7,184	13	215,512	217,257	221,614	78	4,384	209	230,614	222,214
September	204,675	80	8,077	5	226,478	201,861	206,352	75	5,119	12	229,793	212,355
October	198,697	79	6,417	32	221,532	210,107	207,019	80	4,264	2	226,355	214,799
November	198,070	74	4,180	27	232,139	191,690	208,132	83	4,379	15	227,787	211,147
December	210,367	85	3,681	245	234,978	211,049	222,452	81	2,590	206	231,432	221,272
Total	2,378,960	959	67,249	744	234,978	2,436,229	2,502,711	946	47,774	1,143	231,432	2,553,834
Refining district:												
East coast	225,079	--	59,917	2	57,188	815,172	252,506	--	43,506	--	54,240	872,817
Appalachian No. 1	22,943	--			5,672		25,550	--			4,966	
Appalachian No. 2	12,506	--			3,344		14,337	--			2,965	
Indiana, Illinois, Kentucky, etc	459,883	--	1,285	2	42,583	826,519	475,917	--	465	3	34,594	878,271
Minnesota, Wisconsin, etc	52,260	--			7,853		49,990	--			7,800	
Oklahoma, Kansas, etc	207,435	--			22,609		220,791	--			21,732	
Texas inland	93,422	668			9,099		101,784	727			10,130	
Texas gulf coast	528,867	187			26,006		540,637	106			31,643	
Louisiana gulf coast	331,607	--	1,554	600	14,353	361,619	349,999	--	2,212	1,007	18,028	345,728
Arkansas, Louisiana inland, etc	23,148	104			11,015		25,388	113			8,339	
New Mexico	9,909	--			834		9,650	--			781	
Rocky Mountain	83,766	--	22	--	7,141	77,665	86,074	--	--	--	8,280	83,039
West coast	328,135	--	4,471	140	27,281	355,254	350,088	--	1,591	133	27,934	373,979
Total	2,378,960	959	67,249	744	234,978	2,436,229	2,502,711	946	47,774	1,143	231,432	2,553,834

[P]Preliminary.
[1]Includes stocks of gasoline at refineries, bulk terminals, pipelines and gas-processing plants.

Table 25.—Salient statistics of aviation gasoline in the United States, by month and refining district

(Thousand barrels)

	1975				1976[p]			
	Production	Exports	Stocks, end of period	Domestic demand	Production	Exports	Stocks, end of period	Domestic demand
Month:								
January	1,110	9	3,602	978	718	10	2,869	863
February	910	4	3,462	1,046	850	26	2,856	837
March	923	3	3,345	1,037	1,030	39	2,796	1,051
April	884	5	3,048	1,176	880	14	2,552	1,110
May	1,107	8	3,031	1,116	977	4	2,437	1,088
June	1,052	11	2,859	1,213	1,402	5	2,335	1,499
July	1,330	9	2,737	1,443	1,372	8	2,483	1,216
August	1,482	6	2,863	1,350	1,603	14	2,601	1,471
September	1,264	5	2,757	1,365	1,388	22	2,815	1,152
October	1,524	10	2,922	1,349	1,040	4	2,716	1,135
November	1,294	5	3,140	1,071	1,064	4	2,751	1,025
December	838	31	3,024	923	1,008	4	2,840	915
Total	13,718	106	3,024	14,067	13,332	154	2,840	13,362
Refining district:								
East coast	110	27	393	3,210	161	19	447	2,766
Appalachian No. 1	6		45		--		50	
Appalachian No. 2	--	--	1	3,570	--	--	2	3,684
Indiana, Illinois, Kentucky, etc	1,460		691		1,342		565	
Minnesota, Wisconsin, etc	--		102		--		75	
Oklahoma, Kansas, etc	366		126		447		156	
Texas inland	2,047	23	238	3,287	1,806	81	127	3,134
Texas gulf coast	4,054		431		4,046		365	
Louisiana gulf coast	1,926		402		1,992		449	
Arkansas, Louisiana inland, etc	--		7		--		11	
New Mexico	--		14		--		11	
Rocky Mountain	429	--	40	599	506	--	56	777
West coast	3,320	56	534	3,401	3,032	54	526	3,001
Total	13,718	106	3,024	14,067	13,332	154	2,840	13,362

[p]Preliminary.

Table 26.—Shipments of aviation fuel to PAD distr. :ts

(Thousand barrels)

Product and use	District I	District II	District III	District IV	District V	United States
1975						
Aviation gasoline:						
For commercial use:						
Airlines	372	102	68	18	277	837
Factory	34	61	21	--	34	150
General aviation	2,502	2,723	1,703	514	2,013	9,455
Total	2,908	2,886	1,792	532	2,324	10,442
For military use	618	570	831	81	1,342	3,442
Jet fuel:						
For commercial use:						
Kerosine-type:						
Airlines	97,184	50,185	22,310	7,083	70,848	247,610
Factory	1,088	339	309	3	417	2,156
General aviation	3,865	3,175	2,568	352	1,413	11,373
Total	102,137	53,699	25,187	7,438	72,678	261,139
Naphtha-type:						
Airlines	5	126	110	36	32	309
Factory	40	164	--	--	25	229
General aviation	23	61	2	7	667	760
Total	68	351	112	43	724	1,298
Total for commercial use	102,205	54,050	25,299	7,481	73,402	262,437
For military use:						
JP-4[1]	13,511	14,114	14,440	3,291	19,411	64,767
JP-5[1]	9,673	117	1,476	--	[3]7,455	18,721
Other	106	9	222	--	3,182	3,519
Total	23,290	14,240	16,138	3,291	30,048	87,007
For nonaviation use[2]	3,705	724	198	4	307	4,938
1976						
Aviation gasoline:						
For commercial use:						
Airlines	340	135	49	14	262	800
Factory	30	41	27	--	21	119
General aviation	2,658	3,071	1,824	597	2,152	10,302
Total	3,028	3,247	1,900	611	2,435	11,221
For military use	333	335	601	57	626	1,952
Jet fuel:						
For commercial use:						
Kerosine-type:						
Airlines	96,755	49,927	21,590	8,906	70,303	247,481
Factory	818	437	332	6	627	2,220
General aviation	4,109	3,190	3,557	647	1,894	13,397
Total	101,682	53,554	25,479	9,559	72,824	263,098
Naphtha-type:						
Airlines	46	--	--	--	96	142
Factory	233	87	23	--	5	348
General aviation	78	202	3	6	318	607
Total	357	289	26	6	419	1,097
Total for commercial use	102,039	53,843	25,505	9,565	73,243	264,195

See footnotes at end of table.

Table 26.—Shipments of aviation fuel to PAD districts —Continued

(Thousand barrels)

Product and use	District I	District II	District III	District IV	District V	United States
1976 —Continued						
Jet fuel: —Continued						
For military use:						
JP-4[3]	16,020	13,166	13,663	3,205	20,341	66,395
JP-5[3]	7,800	371	933	--	7,268	16,372
Other	56	76	168	--	2,976	3,276
Total	23,876	13,613	14,764	3,205	30,585	86,043
For nonaviation use[4]	3,514	863	110	4	394	4,885

[1]Excludes direct imports by the military of naphtha-type jet into: P.A.D. I, 8,721,000 barrels; P.A.D. V, 1,506,000 barrels. Also excludes direct imports by the military of kerosine-type jet into: P.A.D. I, 100,000 barrels; P.A.D. V, 44,000 barrels.

[2]Includes 3,175,000 barrels sold to electric utilities, and 1,763,000 barrels sold as jet-grade kerosine.

[3]Excludes direct imports by the military of naphtha-type jet fuel into: P.A.D. I, 3,424,000 barrels; P.A.D. V, 1,795,000 barrels. Also excludes direct imports by the military of kerosine-type jet into: P.A.D. V, 904,000 barrels.

[4]Includes 4,234,000 barrels sold to electric utilities, and 651,000 barrels sold as jet-grade kerosine.

Definitions of terms used in this table:

Aviation gasoline—Any fuel in the gasoline boiling range for use in a piston-type aviation engine.

Jet fuel—Any fuel for use in an aviation turbine engine.

Airline—Sales to U.S. certified air carriers, including air freight carriers, and international air carriers (if delivery is made in the United States), and to such other air carriers as supplemental or non-scheduled carriers, air taxi, etc.

Factory—Direct sales to airframe and engine manufacturers. Does not include aviation fuels supplied to these accounts for the Defense Fuel Supply Center (DFSC).

General aviation—All nonmilitary sales which are not classified as airline or factory. Primarily made up of sales to distributors and airport dealers.

Military—Sales to Defense Fuel Supply Center and to other military agencies of the Government.

Nonaviation—Sales for use in turbine engines other than aviation turbine engines. Sales to electric utilities are included in this category.

Table 27.—Salient statistics of jet fuel in the United States, by month and refining district

(Thousand barrels)

	Production			Imports			Exports			Total stocks, end of period			Domestic demand		
	Naphtha-type	Kerosine-type	Total	Naphtha-type	Kerosine-type	Total	Naphtha-type	Kerosine-type	Total	Naphtha-type	Kerosine type	Total	Naphtha-type	Kerosine-type	Total
1975															
Month:															
January	4,294	21,475	25,769	730	6,381	7,111	--	59	59	5,548	24,773	30,321	5,282	26,994	32,276
February	4,651	18,723	23,374	984	4,604	5,588	--	62	62	5,415	23,718	29,133	5,768	24,320	30,088
March	6,157	21,633	27,790	947	3,073	4,020	--	43	43	6,155	24,301	30,456	6,364	24,080	30,444
April	4,967	20,939	25,906	413	3,709	4,122	--	39	39	5,777	24,486	30,263	5,758	24,424	30,182
May	5,672	21,016	26,688	713	3,424	4,137	--	68	68	5,484	25,235	30,719	6,678	23,623	30,301
June	4,901	20,264	25,165	650	2,523	3,173	--	39	39	5,253	24,084	29,337	5,782	23,899	29,681
July	5,820	21,561	27,381	490	2,230	2,720	--	69	69	5,578	24,220	29,798	5,985	23,586	29,571
August	5,812	23,884	29,696	861	3,240	4,101	--	52	52	5,654	25,449	31,103	6,597	25,843	32,440
September	5,735	21,487	27,222	1,420	2,782	4,202	--	45	45	5,797	25,494	31,291	7,012	24,179	31,191
October	6,082	20,689	26,771	818	2,473	3,291	--	44	44	5,864	24,546	30,410	6,833	24,066	30,899
November	6,047	19,866	25,913	998	1,669	2,667	--	41	41	5,812	23,165	28,977	7,097	22,875	29,972
December	5,482	20,824	26,306	1,315	2,076	3,391	--	49	49	5,222	25,158	30,380	7,387	20,858	28,245
Total	65,620	252,361	317,981	10,339	38,184	48,523	--	610	610	5,222	25,158	30,380	76,543	288,747	365,290
Refining district:															
East coast	1,922	13,099	15,021	8,721	19,377	28,098	--	4	4	236	6,234	6,470	22,220	115,652	137,872
Appalachian No. 1	522	527	1,049							42	276	318			
Appalachian No. 2	--	--	--							42	198	240			
Indiana, Illinois, Kentucky, etc	6,762	36,639	43,401	--	769	769	--	1	1	609	3,649	4,258	13,913	54,250	68,163
Minnesota, Wisconsin, etc	1,257	1,804	3,061							107	771	878			
Oklahoma, Kansas, etc	6,064	9,263	15,327							724	1,008	1,732			
Texas inland	6,023	7,371	13,394							454	1,018	1,472			
Texas gulf coast	8,647	53,024	61,671							430	2,271	2,701			
Louisiana gulf coast	7,338	59,374	66,712	112	1,752	1,864	--	--	--	469	2,164	2,633	15,122	27,444	42,566
Arkansas, Louisiana inland, etc	1,618	1	1,619							284	1,400	1,684			
New Mexico	2,257	37	2,294							214	80	294			
Rocky Mountain	4,267	4,730	8,997	--	4	4	--	--	--	188	407	595	3,072	7,813	10,885
West coast	18,943	66,492	85,435	1,506	16,282	17,788	--	605	605	1,423	5,682	7,105	22,216	83,588	105,804
Total	65,620	252,361	317,981	10,339	38,184	48,523	--	610	610	5,222	25,158	30,380	76,543	288,747	365,290

See footnotes at end of table.

Table 27.—Salient statistics of jet fuel in the United States, by month and refining district —Continued

(Thousand barrels)

	Production			Imports			Exports			Total stocks, end of period			Domestic demand		
	Naphtha-type	Kerosine-type	Total	Naphtha-type	Kerosine-type	Total	Naphtha-type	Kerosine-type	Total	Naphtha-type	Kerosine type	Total	Naphtha-type	Kerosine-type	Total
1976[p]															
Month:															
January	5,003	22,565	27,568	323	1,815	2,138	--	89	89	6,143	24,475	30,618	4,405	24,974	29,379
February	4,822	21,789	26,611	642	1,416	2,058	--	115	115	6,151	25,029	31,180	5,456	22,536	27,992
March	5,319	23,426	28,745	164	2,496	2,660	--	52	52	5,724	26,895	32,619	5,910	24,004	29,914
April	5,865	21,936	27,801	357	2,894	3,251	--	48	48	5,765	27,567	33,332	6,181	24,110	30,291
May	6,659	21,209	27,868	906	2,369	3,275	--	45	45	6,671	27,993	34,664	6,659	23,107	29,766
June	5,109	21,251	26,360	445	1,600	2,045	--	39	39	6,365	27,514	33,879	5,860	23,291	29,151
July	5,801	23,131	28,932	529	3,511	4,040	--	56	56	6,079	26,653	32,732	6,616	27,447	34,063
August	5,846	23,353	29,199	271	900	1,171	--	55	55	6,333	26,788	33,121	5,863	24,063	29,926
September	6,524	23,164	29,688	336	1,549	1,885	--	56	56	5,910	27,294	33,204	7,283	24,151	31,434
October	6,113	21,467	27,580	469	1,085	1,554	--	63	63	6,991	27,041	34,032	5,501	22,742	28,243
November	5,665	21,933	27,598	485	1,185	1,670	--	89	89	6,809	27,050	33,859	6,332	23,020	29,352
December	5,746	22,150	27,896	587	1,649	2,236	--	59	59	6,495	25,590	32,085	6,647	25,200	31,847
Total	68,472	267,374	335,846	5,514	22,469	27,983	--	766	766	6,495	25,590	32,085	72,713	288,645	361,358
Refining district:															
East coast	3,181	14,636	17,817	3,719	11,072	14,791	--	--	--	439	6,376	6,815	19,205	113,082	132,287
Appalachian No. 1	541	913	1,454							29	192	221			
Appalachian No. 2	--	--	--							3	142	145			
Indiana, Illinois, Kentucky, etc	6,511	36,165	42,676	--	62	62	--	--	--	637	2,654	3,291	13,443	54,827	68,270
Minnesota, Wisconsin, etc	1,095	2,078	3,173							104	598	702			
Oklahoma, Kansas, etc	6,255	8,572	14,827							864	1,340	2,204			
Texas inland	6,890	7,563	14,453							461	1,201	1,662			
Texas gulf coast	9,339	57,641	66,980							718	3,297	4,015			
Louisiana gulf coast	7,324	64,046	71,370	--	325	325	--	110	110	514	2,330	2,844	14,597	26,634	41,231
Arkansas, Louisiana inland, etc	1,553	144	1,697							313	641	954			
New Mexico	2,482	165	2,647							261	59	320			
Rocky Mountain	4,328	5,410	9,738	--	--	--	--	--	--	261	392	653	3,052	9,811	12,863
West coast	18,973	70,041	89,014	1,795	11,010	12,805	--	656	656	1,891	6,368	8,259	22,416	84,291	106,707
Total	68,472	267,374	335,846	5,514	22,469	27,983	--	766	766	6,495	25,590	32,085	72,713	288,645	361,358

[p]Preliminary.

Table 28.—Salient statistics of ethane (including ethylene) in the United States, by month and refining district

(Thousand barrels)

	1975									
	Production					1976[p] Production				
	At gas-processing plants	At refineries	Total	Total stocks, end of period	Domestic demand	At gas-processing plants	At refineries	Total	Total stocks, end of period	Domestic demand
Month:										
January	10,634	422	11,056	4,709	10,909	10,934	338	11,272	7,483	10,803
February	9,438	305	9,743	4,969	9,483	10,662	456	11,118	8,579	10,022
March	10,448	278	10,726	5,390	10,305	11,203	534	11,737	8,669	11,647
April	9,860	326	10,186	5,619	9,957	10,728	466	11,194	9,192	10,671
May	10,231	336	10,567	6,130	10,056	10,939	517	11,456	9,428	11,220
June	9,732	355	10,087	7,080	9,137	10,476	486	10,962	9,853	10,537
July	10,246	319	10,565	7,330	10,315	11,026	425	11,451	10,663	10,641
August	10,227	359	10,586	7,317	10,599	11,054	516	11,570	11,160	11,073
September	9,736	329	10,065	6,778	10,604	11,209	580	11,789	11,594	11,355
October	10,703	321	11,024	6,389	11,413	11,520	487	12,007	11,855	11,746
November	10,614	352	10,966	6,725	10,630	11,803	416	12,219	12,770	11,304
December	11,076	353	11,429	7,014	11,140	12,100	418	12,518	13,600	11,688
Total	122,945	4,055	127,000	7,014	124,548	133,654	5,639	139,293	13,600	132,707

	1975									
	Production					1976[p] Production				
	At gas-processing plants	At refineries	Total	Total stocks, end of period	Domestic demand	At gas-processing plants	At refineries	Total	Total stocks, end of period	Domestic demand
Refining district:										
East coast	2,084	40	2,124		3,866	3,652	27	3,679		
Appalachian No. 1	1,742	--	1,742	--		1,524	--	1,524	--	5,203
Appalachian No. 2	--	--	--			--	--	--		
Indiana, Illinois, Kentucky, etc	6,609	--	6,609	1,707	15,213	6,456	--	6,456	2,518	16,321
Minnesota, Wisconsin, etc	--	--	--			--	--	--		
Oklahoma, Kansas, etc	8,409	352	8,761			10,212	464	10,676		
Texas inland	45,813	80	45,893			49,829	215	50,044		
Texas gulf coast	14,831	2,609	17,440			17,654	3,457	21,111		
Louisiana gulf coast	36,389	634	37,023	5,306	103,867	33,433	971	34,404	11,081	108,147
Arkansas, Louisiana inland, etc	889	--	889			1,074	--	1,074		
New Mexico	4,919	--	4,919			7,289	--	7,289		
Rocky Mountain	1,260	--	1,260	1	1,262	2,531	--	2,531	1	2,531
West coast	--	340	340	--	340	--	505	505	--	505
Total	122,945	4,055	127,000	7,014	124,548	133,654	5,639	139,293	13,600	132,707

[p]Preliminary.

Table 29.—Salient statistics of liquefied gases (excluding ethane) in the United States, by month and refining district

(Thousand barrels unless otherwise indicated)

	1975								1976[p]							
	Refinery production	Yield (percent)	Production at gas-processing plants	Imports	Exports	LPG used at refineries	Total stocks, end of period	Domestic demand	Refinery production	Yield (percent)	Production at gas-processing plants	Imports	Exports	LPG used at refineries	Total stocks, end of period	Domestic demand
Month:																
January	9,106	2.3	27,398	5,538	925	9,431	98,062	41,604	9,117	2.3	26,288	4,824	750	9,368	101,538	46,707
February	7,971	2.3	25,267	3,237	847	7,732	93,509	32,449	8,721	2.3	25,306	4,140	665	8,104	96,945	33,991
March	8,395	2.3	28,251	2,962	989	7,658	91,738	32,732	9,786	2.5	26,370	3,886	805	7,593	99,852	28,737
April	7,858	2.2	26,857	3,053	870	5,991	95,775	26,870	10,010	2.6	24,989	2,551	784	6,468	104,791	25,359
May	8,930	2.5	26,745	1,179	784	5,637	105,539	20,669	11,138	2.8	25,495	2,773	697	6,555	112,880	24,065
June	9,346	2.5	26,107	2,776	667	5,483	117,033	20,585	10,192	2.5	24,455	3,425	841	6,838	120,508	22,765
July	10,106	2.5	26,932	3,042	713	6,283	123,914	26,203	10,542	2.5	25,092	2,744	740	6,838	127,750	23,558
August	10,708	2.6	27,598	2,533	741	6,266	131,152	26,594	10,695	2.4	24,760	3,353	665	6,907	132,455	26,531
September	9,446	2.4	25,291	3,622	708	7,220	134,845	26,738	9,968	2.4	24,297	3,208	627	7,783	135,598	25,920
October	9,292	2.4	27,056	4,308	768	8,105	134,183	32,445	9,092	2.3	25,671	5,342	755	8,233	132,044	34,671
November	8,913	2.4	26,275	3,900	654	9,390	131,358	31,869	9,526	2.3	25,305	5,315	773	8,851	121,469	41,097
December	9,262	2.3	27,364	4,577	822	10,466	118,134	43,139	10,142	2.3	25,684	5,875	891	11,722	102,695	47,862
Total	109,333	2.4	321,141	40,727	9,488	89,662	118,134	361,897	118,929	2.4	303,712	47,436	8,993	95,260	102,695	381,263
Refining district:																
East coast	14,388	3.0	7,594	6,716	22	93	5,434	65,833	18,102	3.4	8,672	6,066	36	21	3,507	71,295
Appalachian No. 1	1,008	1.8				71			1,556	2.5				175		
Appalachian No. 2	377	1.8				793			400	1.8				1,402		
Indiana, Illinois, Kentucky, etc	18,150	2.3	52,517	17,894	19	17,318	34,591	131,916	19,147	2.3	52,326	21,938	162	18,463	29,547	137,611
Minnesota, Wisconsin, etc	1,977	2.3				3,182			2,341	2.5				3,441		
Oklahoma, Kansas, etc	6,669	2.0				12,240			7,768	2.1				13,220		
Texas inland	3,569	2.2				6,134			3,589	2.1				6,682		
Texas gulf coast	28,809	2.8				14,720			29,453	2.6				17,399		
Louisiana gulf coast	14,941	2.2	244,689	5,386	7,755	22,514	75,195	134,623	16,961	2.4	225,547	6,773	7,475	21,696	66,683	135,064
Arkansas, Louisiana inland, etc	1,194	2.1				1,092			1,064	1.8				1,095		
New Mexico	606	2.3				523			528	1.9				531		
Rocky Mountain	2,076	1.3	11,770	5,706	--	3,635	716	11,402	2,166	1.3	12,927	5,888	1	4,200	855	16,437
West coast	15,569	2.2	4,571	5,025	1,692	7,347	2,198	18,123	15,854	2.1	4,240	6,771	1,319	6,935	2,103	20,856
Total	109,333	2.4	321,141	40,727	9,488	89,662	118,134	361,897	118,929	2.4	303,712	47,436	8,993	95,260	102,695	381,263

[p]Preliminary.

Table 30.—Salient statistics of kerosine in the United States, by month and refining district

(Thousand barrels unless otherwise indicated)

	1975							1976[p]						
	Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks, end of period	Domestic demand	Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks, end of period	Domestic demand
Month:														
January	6,101	1.6	16	299	3	16,466	6,814	5,559	1.4	16	8	9	11,906	9,239
February	5,715	1.6	13	234	2	15,348	7,078	5,410	1.5	13	368	1	11,379	6,317
March	4,878	1.3	19	107	--	15,170	5,182	5,009	1.3	16	264	4	11,744	4920
April	4,462	1.3	19	--	12	15,255	4,384	3,908	1.0	16	251	2	11,748	4,169
May	4,217	1.2	16	42	1	16,512	3,017	3,512	.9	14	61	2	12,914	2,419
June	2,790	.7	16	--	6	15,351	3,961	3,511	.9	8	237	1	13,051	3,618
July	3,697	.9	14	--	2	16,038	3,022	3,333	.8	11	97	4	13,403	3,085
August	4,342	1.1	14	80	4	17,153	3,317	4,286	1.0	10	178	4	14,951	2,922
September	4,344	1.1	13	15	--	17,775	3,750	4,452	1.1	16	253	8	15,178	4,486
October	4,426	1.1	13	98	12	17,772	4,528	4,782	1.2	6	487	2	15,676	4,825
November	4,719	1.2	12	141	4	18,237	4,403	4,912	1.2	12	328	--	14,404	6,474
December	5,804	1.5	13	57	6	15,571	8,534	6,917	1.5	11	631	3	12,514	9,446
Total or average	55,495	1.2	178	1,073	52	15,571	57,990	55,591	1.1	149	3,163	40	12,514	61,920
Refining district:														
East coast	3,501	.7	--	1,073	8	6,790	24,701	3,335	.6	--	3,163	3	6,052	29,651
Appalachian No. 1	1,638	2.8	--			517		1,642	2.6	--			400	
Appalachian No. 2	626	2.9	--			294		800	3.5	--			256	
Indiana, Illinois, Kentucky, etc	11,810	1.5	--	--	2	3,014	16,138	11,425	1.4	--	--	15	1,521	17,829
Minnesota, Wisconsin, etc	234	.3	--			185		255	.3	--			94	
Oklahoma, Kansas, etc	1,035	.3	--			478		765	.2	--			258	
Texas inland	1,102	.7	117			155		649	.4	99			112	
Texas gulf coast	21,219	2.0	27			2,241	13,263	21,803	2.0	14	--	12	1,752	10,582
Louisiana gulf coast	8,227	1.3	--	--	32	614		9,054	1.3	--			891	
Arkansas, Louisiana inland, etc	632	1.1	1			621		560	.9	--			501	
New Mexico	1,475	5.6	33			32		1,468	5.5	36			69	
Rocky Mountain	1,016	.6	--	--	--	288	884	601	.4	--	--	--	184	717
West coast	2,980	.4	--	--	10	342	3,004	3,234	.4	--	--	10	424	3,141
Total or average	55,495	1.2	178	1,073	52	15,571	57,990	55,591	1.1	149	3,163	40	12,514	61,920

[p]Preliminary.

Table 31.—Sales of distillate fuel oil[1] in the United States in 1972-76, by use

(Million barrels)

Use	1972	1973	1974	1975	1976
Heating[2]	543.3	536.9	493.2	488.4	544.3
Industrial (excluding oil-company use)	60.4	67.3	64.0	64.0	79.5
Oil-company use	13.4	14.9	13.8	13.6	13.5
Electric utility companies	68.3	77.9	84.7	[3]63.4	[4]60.5
Railroads	97.0	102.8	103.0	93.2	99.9
Vessels	22.2	26.8	24.8	26.1	27.0
Military	20.2	19.6	17.8	18.0	17.6
On-highway diesel	189.1	221.4	221.0	217.9	242.8
Off-highway diesel	50.2	55.5	48.7	49.0	54.4
All other	10.8	11.9	10.1	10.1	11.4
Total	1,074.9	1,135.0	1,081.1	1,043.7	1,150.9

[1]Includes diesel fuel.

[2]Includes range oil.

[3]Includes 19.7 million barrels of distillate No. 2, 2.5 million barrels of distillate No. 4 fuel oil used at steam-electric plants, and 3.2 million barrels of kerosine-type jet fuel used by electric utility companies.

[4]Includes 22.4 million barrels of distillate No. 2, 2.2 million barrels of distillate No. 4 fuel oil used at steam-electric plants, and 4.2 million barrels of kerosine-type jet fuel used by electric utility companies.

Table 32.—Salient statistics of distillate fuel oil in the United States, by month and refining district

(Thousand barrels unless otherwise indicated)

	1975								1976[p]							
	Production at refineries	Yield (percent)	Production at gas processing plants	Crude used directly as distillate[1]	Imports	Exports	Total stocks, end of period	Domestic demand	Production at refineries	Yield (percent)	Production at gas-processing plants	Crude used directly as distillate[1]	Imports	Exports	Total stocks, end of period	Domestic demand
Month:																
January	88,418	22.6	20	53	10,355	2	199,752	122,848	84,750	21.7	16	44	5,074	7	165,477	133,233
February	75,005	22.1	16	48	8,453	50	176,734	106,490	85,870	23.0	14	42	6,011	24	150,472	106,918
March	78,480	21.4	19	49	7,911	1	161,149	102,043	86,596	21.9	18	46	4,671	35	138,340	103,428
April	74,595	21.2	20	59	3,297	51	146,257	92,812	79,652	20.9	14	48	2,875	15	137,285	83,629
May	75,366	20.6	20	61	4,225	7	152,070	73,852	84,878	21.1	15	43	2,993	21	147,097	78,096
June	77,216	20.5	18	43	2,072	48	163,348	68,023	86,550	20.9	17	43	4,517	26	165,110	73,088
July	80,282	19.8	19	47	3,219	11	181,514	65,390	91,733	21.3	17	47	3,917	15	190,900	69,909
August	80,346	19.9	17	47	2,854	49	197,364	67,365	92,429	21.2	14	47	4,059	125	217,969	69,355
September	84,358	21.5	16	49	3,885	1	220,776	64,895	88,405	21.6	12	49	4,408	38	232,268	78,537
October	85,083	22.1	17	43	3,232	1	226,160	82,990	92,856	22.5	13	43	4,371	28	325,638	93,885
November	83,004	21.9	15	43	2,894	10	235,798	76,308	95,410	22.6	13	43	4,039	43	223,685	111,415
December	86,283	21.6	17	45	4,281	36	208,833	117,555	100,903	22.6	14	45	5,535	44	185,986	144,152
Total or average	968,436	21.3	214	587	56,678	267	[2]208,833	1,040,571	1,070,032	21.8	177	540	52,470	421	[2]185,986	1,145,645
By refining district:																
East coast	105,603	22.2							129,005	24.1						
Appalachian No. 1	15,361	26.6	--	--	54,300	3	85,551	466,847	16,015	25.7	--	--	49,044	10	73,669	509,485
Appalachian No. 2	5,242	24.5							5,434	24.1						
Indiana, Illinois, Kentucky, etc	168,313	21.1							182,154	21.8						
Minnesota, Wisconsin, etc	22,906	26.3	--	280	223	5	64,922	315,951	25,540	27.2	--	280	97	12	53,592	360,981
Oklahoma, Kansas, etc	88,376	25.9							96,758	26.5						

See footnotes at end of table.

Table 32.—Salient statistics of distillate fuel oil in the United States, by month and refining district —Continued

(Thousand barrels unless otherwise indicated)

	1975								1976[P]							
	Production at refineries	Yield (percent)	Production at gas processing plants	Crude used directly as distillate[1]	Imports	Exports	Total stocks, end of period	Domestic demand	Production at refineries	Yield (percent)	Production at gas-processing plants	Crude used directly as distillate[1]	Imports	Exports	Total stocks, end of period	Domestic demand
By refining district: —Continued																
Texas inland	31,690	19.8	114						38,407	22.2	104					
Texas gulf coast	239,224	23.2	27						259,082	23.3	7					
Louisiana gulf coast	142,120	22.4	52						156,138	22.2	45					
				191	1,441	61	42,388	121,549				191	680	55	40,548	131,975
Arkansas, Louisiana inland, etc	12,145	21.4	21						14,997	24.3	21					
New Mexico	6,749	25.7	--						6,830	25.5	--					
Rocky Mountain	46,382	29.3	--	69	1	--	3,544	39,954	47,395	28.8	--	69	--	--	4,136	41,624
West coast	84,325	11.9	--	47	713	198	12,428	96,270	92,277	12.1	--	--	2,649	344	14,041	101,580
Total or average	968,436	21.3	214	587	56,678	267	[2]208,833	1,040,571	1,070,032	21.8	177	540	52,470	421	[2]185,986	1,145,645

[P]Preliminary.
[1]Represents crude oil used as fuel on pipelines, which is considered part of the demand for distillate.
[2]No. 4 fuel oil, in thousands of barrels: PAD district I, 1975, 3,911; 1976, 3,935; PAD district II, 1975, 83; 1976, 59; PAD district III, 1975, 376; 1976, 594; PAD district IV, 1975, 9; PAD distric V, 1975, 656; 1976, 224.

Table 33.—Salient statistics of residual fuel oil in the United States, by month and refining district

(Thousand barrels unless otherwise indicated)

	1975							1976[p]						
	Production	Yield (percent)	Crude used directly as residual[1]	Imports	Exports	Stocks, end of period	Domestic demand	Production	Yield (percent)	Crude used directly as residual[1]	Imports	Exports	Stocks, end of period	Domestic demand
Month:														
January	43,857	11.2	371	51,374	463	69,233	100,845	43,876	11.2	550	43,600	416	66,592	95,144
February	37,912	11.1	371	39,269	528	66,495	79,762	40,414	10.8	507	49,401	865	68,859	87,190
March	40,260	11.0	341	40,074	295	64,148	82,727	40,628	10.3	504	41,610	312	65,132	86,157
April	37,335	10.6	391	31,618	178	66,340	66,974	38,486	10.1	512	37,728	532	66,458	74,868
May	35,678	9.8	451	35,965	246	73,498	64,690	38,958	9.7	516	35,151	313	65,147	75,623
June	34,569	9.2	451	27,071	619	69,660	65,310	37,226	9.0	518	37,188	210	64,272	75,597
July	35,798	8.8	559	34,863	540	71,526	68,814	39,251	9.1	510	45,316	332	69,812	79,205
August	35,522	8.8	399	31,641	371	71,857	66,860	40,941	9.4	486	40,510	245	68,490	83,014
September	35,500	9.1	682	39,322	577	76,938	69,846	39,912	9.7	528	43,269	253	76,436	75,510
October	36,130	9.4	482	38,792	164	81,858	70,320	41,885	10.1	554	38,246	153	79,117	77,851
November	36,426	9.6	623	36,762	376	83,181	72,162	47,431	11.2	562	44,232	465	73,284	97,593
December	41,970	10.5	495	39,777	985	74,126	90,262	54,945	12.3	551	55,514	114	72,344	111,836
Total or average	[2]450,957	9.9	5,616	[3]446,528	5,342	74,126	898,572	[2]503,953	10.3	6,298	[3]511,765	4,210	72,344	1,019,588
By refining district:														
East coast	61,962	13.0	--	[4]416,105	12	37,944	545,713	61,669	11.5	--	[5]492,096	18	39,061	608,487
Appalachian No. 1	6,272	10.8						5,977	9.6					
Appalachian No. 2	1,700	8.0						1,704	7.6					
Indiana, Illinois, Kentucky, etc	50,723	6.4	579	14,015	114	9,897	91,177	61,698	7.4	579	[5]11,722	89	7,339	106,974
Minnesota, Wisconsin, etc	6,852	7.9						6,202	6.6					
Oklahoma, Kansas, etc	10,415	3.0						15,650	4.3					
Texas inland	11,597	7.2						9,264	5.4					
Texas gulf coast	90,259	8.7						104,746	9.4					
Louisiana gulf coast	46,508	7.3	1,783	3,957	458	9,242	103,075	57,650	8.2	1,783	1,728	920	12,735	125,730
Arkansas, Louisiana inland, etc	10,744	18.9						9,210	14.9					
New Mexico	4,851	18.5						5,440	20.3					
Rocky Mountain	13,030	8.2	252	--	--	1,006	13,198	14,436	8.8	252	--	--	814	14,836
West coast	136,044	19.2	3,002	[4]12,451	4,758	16,037	145,409	150,307	19.8	3,684	[5]6,219	3,183	12,395	163,561

See footnotes at end of table.

Table 33.—Salient statistics of residual fuel oil in the United States, by month and refining district —Continued

(Thousand barrels unless otherwise indicated)

	1975							1976[p]						
	Production	Yield (percent)	Crude used directly as residual[1]	Imports	Exports	Stocks, end of period	Domestic demand	Production	Yield (percent)	Crude used directly as residual[1]	Imports	Exports	Stocks, end of period	Domestic demand
By refining district: —Continued														
Total or average	[2]450,957	9.9	5,616	[3]446,528	5,342	74,126	898,572	[2]503,953	10.3	6,298	[3]511,765	4,210	72,344	1,019,588

[p]Preliminary.
[1]Represents crude oil used as fuel on leases and for general industrial purposes.
[2]Sulfur content in thousands of barrels: 0-0.50%, 1975: 108,943; 1976: 128,396, 0.51%-1.00%, 1975: 111,516; 1976: 118,951, 1.01%-2.00%, 1975: 123,469; 1976: 127,949, over 2.00%, 1975: 107,029; 1976: 128,657.
[3]Sulfur content in thousands of barrels: 0-0.50%, 1975: 173,760; 1976: 172,771, 0.51%-1.00%, 1975: 68,778; 1976: 106,898, 1.01%-2.00%, 1975: 67,511; 1976: 70,257, over 2.00%, 1975: 114,674; 1976: 146,475.
[4]Includes foreign crude oil to be burned as fuel, in thousands of barrels. District I: 6,588; District II: 6,312; District V: 659.
[5]Includes foreign crude oil to be burned as fuels, in thousands of barrels. District II: 5,553.

Table 34.—Salient statistics of petrochemical feedstocks[1] in the United States, by month and refining district

(Thousand barrels)

	Production				Imports (naphtha 400°)	Exports (other)	Stocks, end of period			Domestic demand (all types)
	Still gas	Naphtha 400°	Other	Total			Naphtha 400°	Other	Total	
1975										
Month:										
January	1,313	4,790	4,661	10,764	974	377	2,027	1,861	3,888	10,959
February	1,145	3,418	3,011	7,574	--	406	1,857	1,602	3,459	7,597
March	1,077	4,259	4,139	9,475	93	696	1,780	1,528	3,308	9,023
April	1,155	3,932	3,177	8,264	--	839	1,806	1,669	3,475	7,258
May	1,070	3,760	3,344	8,174	100	549	1,550	1,497	3,047	8,153
June	1,298	4,346	3,912	9,556	336	627	1,379	1,468	2,847	9,465
July	1,379	4,632	4,611	10,622	--	638	1,443	1,208	2,651	10,180
August	1,430	4,733	5,144	11,307	380	1,139	1,529	1,176	2,705	10,494
September	1,309	5,418	4,811	11,538	--	893	1,773	1,252	3,025	10,325
October	1,482	5,076	4,811	11,369	--	528	1,541	1,198	2,739	11,127
November	1,704	5,372	4,730	11,806	--	478	1,587	1,400	2,987	11,080
December	1,361	5,034	5,343	11,738	178	867	1,540	1,384	2,924	11,112
Total	15,723	54,770	51,694	122,187	2,061	8,037	1,540	1,384	2,924	116,773
Refining district:										
East coast	586	5,602	207	6,395	378	410	--	167	167	10,683
Appalachian No. 1	174	--	229	403			--	23	23	
Appalachian No. 2	--	--	--	--			--	--	--	
Indiana, Illinois, Kentucky, etc	1,302	2,865	1,694	5,861	--	319	68	101	169	7,818
Minnesota, Wisconsin, etc	59	--	--	59			--	--	--	
Oklahoma, Kansas, etc	--	663	141	804			76	14	90	
Texas inland	293	5,434	3,228	8,955			185	234	419	
Texas gulf coast	10,987	34,630	23,249	68,866			812	326	1,138	
Louisiana gulf coast	759	1,582	21,635	23,976	1,683	5,564	50	291	341	93,611
Arkansas, Louisiana inland, etc	--	271	233	504			3	5	8	
New Mexico	54	--	--	54			--	--	--	
Rocky Mountain	935	--	--	935	--	17	--	--	--	918
West coast	574	3,723	1,078	5,375	--	1,727	346	223	569	3,743
Total	15,723	54,770	51,694	122,187	2,061	8,037	1,540	1,384	2,924	116,773

See footnotes at end of table.

Table 34.—Salient statistics of petrochemical feedstocks[1] in the United States, by month and refining district —Continued

(Thousand barrels)

	Production				Imports (naphtha 400°)	Exports (other)	Stocks, end of period			Domestic demand (all types)
	Still gas	Naphtha 400°	Other	Total			Naphtha 400°	Other	Total	
1976[p]										
Month:										
January	1,598	6,041	5,424	13,063	581	265	1,702	1,575	3,277	13,026
February	1,406	6,326	5,423	13,155	233	989	2,025	1,186	3,211	12,465
March	1,465	6,708	5,865	14,038	--	493	1,903	1,537	3,440	13,316
April	1,253	6,311	5,381	12,945	93	909	1,713	1,430	3,143	12,426
May	1,615	6,757	5,028	13,400	--	336	1,790	1,660	3,450	12,757
June	1,550	6,409	4,532	12,491	286	603	1,598	1,669	3,267	12,357
July	1,456	7,191	6,236	14,883	--	789	1,935	1,732	3,667	13,694
August	1,076	6,722	5,970	13,768	177	622	2,028	1,859	3,887	13,103
September	1,070	7,341	5,046	13,457	--	839	3,119	1,765	4,884	11,621
October	1,224	6,695	5,488	13,407	--	380	2,758	2,144	4,902	13,009
November	1,396	6,809	6,290	14,495	--	3,375	2,813	1,969	4,782	11,240
December	2,339	6,783	6,196	15,318	--	1,544	3,223	1,491	4,714	13,842
Total	17,448	80,093	66,879	164,420	1,370	11,144	3,223	1,491	4,714	152,856
Refining district:										
East coast	758	7,021	152	7,931	--	242	75	2	77	11,401
Appalachian No. 1	38	--	--	38			--	--	--	
Appalachian No. 2	--	--	--	--			--	--	--	
Indiana, Illinois, Kentucky, etc	2,915	4,408	2,337	9,660	--	308	105	223	328	11,902
Minnesota, Wisconsin, etc	--	44	--	44			8	--	8	
Oklahoma, Kansas, etc	--	998	268	1,266			61	10	71	
Texas inland	254	5,086	3,137	8,477			130	199	329	
Texas gulf coast	10,381	52,539	29,475	92,395			1,270	446	1,716	
Louisiana gulf coast	935	7,708	28,757	37,400	1,370	9,138	1,019	427	1,446	124,212
Arkansas, Louisiana inland, etc	169	11	262	442			--	25	25	
New Mexico	--	--	--	--			--	--	--	
Rocky Mountain	1,014	--	--	1,014	--	5	--	--	--	1,009
West coast	984	2,278	2,491	5,753	--	1,451	555	159	714	4,332
Total	17,448	80,093	66,879	164,420	1,370	11,144	3,223	1,491	4,714	152,856

[p]Preliminary.
[1]Produced at petroleum refineries (excluding ethane and liquefied gases).

Table 35.—Salient statistics of special naphthas in the United States, by month and refining district

(Thousand barrels unless otherwise indicated)

	1975							1976[p]						
	Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks, end of period	Domestic demand	Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks, end of period	Domestic demand
Month:														
January	2,084	0.5	12	--	140	5,535	2,141	2,510	0.7	7	2	105	4,582	2,209
February	1,990	1.0	12	30	151	5,317	2,099	2,357	.6	7	1	98	4,438	2,411
March	2,117	.6	12	1	55	5,606	1,786	2,709	.7	6	2	244	4,311	2,600
April	1,897	.5	12	1	47	5,173	2,296	2,674	.7	--	3	294	4,112	2,582
May	2,339	.6	12	1	118	5,046	2,361	2,583	.7	--	2	141	3,919	2,637
June	2,140	.6	11	--	94	5,000	2,103	2,834	.7	--	3	141	3,737	2,878
July	2,368	.6	10	2	103	4,469	2,808	2,798	.7	--	3	131	3,732	2,675
August	2,128	.5	9	1	90	4,360	2,157	2,974	.7	--	3	926	3,831	1,952
September	2,558	.7	8	2	112	4,481	2,385	2,700	.7	--	8	112	3,703	2,724
October	2,833	.6	9	2	104	4,302	2,419	2,992	.7	--	5	104	3,993	2,603
November	2,552	.7	9	1	72	4,366	2,426	2,629	.7	--	5	70	4,129	2,428
December	2,694	.7	9	2	135	4,377	2,559	2,858	.7	--	8	144	4,441	2,410
Total	27,200	.6	125	43	1,221	4,377	27,490	32,618	.7	20	45	2,510	4,441	30,109
Refining district:														
East coast	163	--	--	--	174	965	7,530	99	--	--	--	313	679	8,413
Appalachian No. 1	142	.3	--			69		264	.4	--			66	
Appalachian No. 2	150	.7	--			26		128	.5	--			41	
Indiana, Illinois, Kentucky, etc	3,689	.5	--	43	141	799	8,401	3,774	.5	--	45	173	712	10,109
Minnesota, Wisconsin, etc	--	--	--			61		--	--	--			51	
Oklahoma, Kansas, etc	2,170	.6	--			205		2,802	.8	--			204	
Texas inland	994	.6	--			103		1,611	.9	--			138	
Texas gulf coast	14,210	1.4	--			1,379		17,246	1.5	--			1,702	
Louisiana gulf coast	134	--	--	--	840	40	7,606	1,155	.2	--	--	1,931	137	8,376
Arkansas, Louisiana inland, etc	1,730	3.0	125			248		2,257	3.7	20			157	
New Mexico	--	--	--			--		--	--	--			--	
Rocky Mountain	65	--	--	--	3	16	68	107	.1	--	--	3	13	108
West coast	3,753	.5	--	--	63	466	3,885	3,175	.4	--	--	90	541	3,103
Total	27,200	.6	125	43	1,221	4,377	27,490	32,618	.7	20	45	2,510	4,441	30,109

[p]Preliminary.

Table 36.—Salient statistics of lubricants in the United States, by month and refining district

(Thousand barrels unless otherwise indicated)

	Production				Yield (percent)	Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Bright stock	Neutral	Other grades	Total				Bright stocks	Neutral	Other grades	Total	
1975												
Month:												
January	637	2,274	1,950	4,861	1.3	90	820	1,690	5,754	8,215	15,659	4,533
February	443	1,468	1,743	3,654	1.0	184	767	1,737	5,544	8,262	15,543	3,187
March	497	2,205	1,941	4,643	1.3	137	587	1,697	5,910	8,879	16,486	3,250
April	468	1,983	1,953	4,404	1.3	150	686	1,630	5,626	8,789	16,045	4,309
May	550	1,995	1,980	4,525	1.2	1	955	1,524	5,335	8,547	15,406	4,210
June	539	2,211	1,882	4,632	1.2	71	740	1,502	5,144	8,250	14,896	4,473
July	542	2,296	1,957	4,795	1.2	137	860	1,396	5,291	8,038	14,725	4,243
August	572	2,152	1,948	4,672	1.1	81	710	1,305	4,738	8,116	14,159	4,609
September	524	2,508	1,818	4,850	1.2	67	652	1,309	4,759	7,913	13,981	4,443
October	627	2,518	1,933	5,078	1.3	202	1,060	1,285	4,615	7,443	13,343	4,858
November	648	2,417	1,926	4,991	1.3	106	558	1,457	4,991	7,730	14,178	3,704
December	500	2,487	2,129	5,116	1.2	109	716	1,522	5,168	7,647	14,337	4,350
Total	6,547	26,514	23,160	56,221	1.2	1,335	9,1[illegible]	1,522	5,168	7,647	14,337	50,169
Refining district:												
East coast	582	2,092	2,701	5,375	1.1	1,265	[illegible],824	183	555	2,059	2,797	20,025
Appalachian No. 1	1,414	2,654	283	4,[illegible]	7.5			441	386	363	1,190	
Appalachian No. 2	--	--	--	--	--			--	--	77	77	
Indiana, Illinois, Kentucky, etc	171	2,193	1,293	[illegible],657	.5	9	233	80	631	1,004	1,715	11,375
Minnesota, Wisconsin, etc	--	--	--	--	--			--	--	26	26	
Oklahoma, Kansas, etc	508	2,583	1,639	4,730	1.4			126	469	211	806	
Texas inland	--	--	--	--	--			--	--	13	13	
Texas gulf coast	2,040	8,529	13,953	24,522	2.4			324	1,622	2,524	4,470	
Louisiana gulf coast	498	5,131	766	6,395	1.0	59	5,272	91	861	363	1,315	13,043
Arkansas, Louisiana inland, etc	--	719	1,169	1,888	3.3			--	90	272	362	
New Mexico	--	--	--	--	--			--	--	3	3	
Rocky Mountain	35	281	19	335	.2	--	5	13	66	12	91	495
West coast	1,299	2,332	1,337	4,968	.7	2	777	264	488	720	1,472	5,231
Total	6,547	26,514	23,160	56,221	1.2	1,335	9,111	1,522	5,168	7,647	14,337	50,169

1976[p]												
Month:												
January	462	2,396	1,522	4,380	1.1	162	451	1,542	5,386	7,701	14,629	3,799
February	517	2,015	1,720	4,252	1.2	45	877	1,670	4,952	7,358	13,980	4,069
March	370	2,588	1,901	4,859	1.2	73	619	1,407	4,836	6,739	12,982	5,311
April	470	2,312	2,337	5,119	1.3	77	981	1,344	4,363	6,752	12,459	4,738
May	611	2,512	2,237	5,360	1.3	163	741	1,401	4,192	7,125	12,718	4,523
June	468	2,661	2,217	5,346	1.3	60	721	1,277	4,022	7,105	12,404	4,999
July	582	2,597	2,106	5,285	1.2	79	797	1,266	3,788	6,778	11,832	5,139
August	638	2,823	2,036	5,497	1.2	92	753	1,306	4,018	6,840	12,164	4,504
September	641	2,656	2,140	5,437	1.3	289	899	1,422	4,037	6,644	12,103	4,888
October	490	2,762	2,275	5,527	1.3	28	921	1,151	4,007	6,988	12,146	4,591
November	631	2,613	2,144	5,388	1.3	171	857	1,299	4,128	6,891	12,318	4,530
December	836	2,763	1,754	5,353	1.2	122	878	1,506	4,087	6,681	12,274	4,641
Total	6,716	30,698	24,389	61,803	1.3	1,361	9,495	1,506	4,087	6,681	12,274	55,732
Refining district:												
East coast	790	2,448	3,005	6,243	1.2	1,244	3,006	121	442	1,905	2,468	22,075
Appalachian No. 1	1,502	2,860	268	4,630	7.4			381	399	327	1,107	
Appalachian No. 2	--	--	--	--	--			--	--	67	67	
Indiana, Illinois, Kentucky, etc	296	2,648	1,411	4,355	.5	2	243	101	616	1,060	1,777	12,917
Minnesota, Wisconsin, etc	--	--	--	--	--			--	--	25	25	
Oklahoma, Kansas, etc	661	2,976	1,661	5,298	1.5			101	339	175	615	
Texas inland	--	--	78	78	--			--	--	61	61	
Texas gulf coast	2,444	9,308	14,289	26,041	2.3			564	1,092	1,816	3,472	
Louisiana gulf coast	451	6,009	931	7,391	1.1	113	5,496	47	639	330	1,016	14,431
Arkansas, Louisiana inland, etc	--	809	1,123	1,932	3.1			--	38	147	185	
New Mexico	--	--	--	--	--			--	--	3	3	
Rocky Mountain	45	318	22	385	.2	--	2	16	83	11	110	798
West coast	527	3,322	1,601	5,450	.7	2	748	175	439	754	1,368	5,511
Total	6,716	30,698	24,389	61,803	1.3	1,361	9,495	1,506	4,087	6,681	12,274	55,732

[p]Preliminary.

Table 37.—Salient statistics of wax in the United States, by type, month, and refining district

(Thousand barrels)[1]

	Production				Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Microcrystalline	Crystalline, fully refined	Crystalline, other	Total			Microcrystalline	Crystalline, fully refined	Crystalline, other	Total	
1975											
By month:											
January	89	152	217	458	55	30	196	468	424	1,088	590
February	43	102	135	280	78	28	191	436	387	1,014	404
March	58	124	133	315	58	70	185	413	371	969	348
April	73	158	193	424	114	33	174	383	419	976	498
May	75	188	173	436	4	77	177	367	403	947	392
June	61	181	198	440	33	40	170	373	416	959	421
July	83	234	213	530	57	71	163	389	399	951	524
August	96	233	200	529	8	47	172	350	390	912	529
September	89	198	200	487	72	58	160	293	354	807	596
October	98	252	258	608	87	64	146	265	332	743	695
November	84	270	265	619	64	48	146	312	394	817	568
December	83	246	210	539	64	48	146	312	403	861	511
Total	932	2,338	2,395	5,665	684	607	146	312	403	861	6,076
By refining district:											
East coast	39	304	--	343	668	87	7	48	18	73	1,718
Appalachian No. 1	137	26	397	560			38	6	83	127	
Appalachian No. 2	--	--	--	--			--	--	--	--	
Indiana, Illinois, Kentucky, etc	--	209	99	308			--	7	10	17	
Minnesota, Wisconsin, etc	--	--	--	--	2	23	--	--	--	--	1,421
Oklahoma, Kansas, etc	193	200	592	985			44	45	15	104	
Texas inland	48	--	--	48			11	--	--	11	
Texas gulf coast	127	557	951	1,635			30	20	226	276	
Louisiana gulf coast	33	638	52	723	14	445	15	144	24	183	2,191
Arkansas, Louisiana inland, etc	355	--	--	355			1	--	--	1	
New Mexico	--	--	--	--			--	--	--	--	
Rocky Mountain	--	41	--	41	--	--	--	6	--	6	113
West coast	--	363	304	667	--	52	--	36	27	63	633
Total	932	2,338	2,395	5,775	684	607	146	312	403	861	6,076

1976[p]											
By month:											
January	82	262	210	554	61	37	138	306	380	824	615
February	67	219	201	487	32	67	110	283	337	730	546
March	60	258	221	539	62	33	89	283	311	683	614
April	76	242	271	589	63	66	81	273	339	693	576
May	77	274	254	605	88	41	82	294	343	719	626
June	66	278	257	601	47	30	75	321	353	749	588
July	87	263	230	580	62	65	83	300	320	703	623
August	82	296	298	676	65	52	84	329	371	784	608
September	76	277	253	606	38	52	87	316	320	723	653
October	75	274	259	608	9	46	66	313	327	706	588
November	72	250	243	565	64	50	81	303	320	704	581
December	74	294	230	598	61	86	65	322	299	686	591
Total	894	3,187	2,927	7,008	652	625	65	322	299	686	7,209
By refining district:											
East coast	31	241	119	391	624	108	4	13	1	18	1,928
Appalachian No. 1	157	31	440	628			26	11	63	100	
Appalachian No. 2	--	--	--	--			--	--	--	--	
Indiana, Illinois, Kentucky, etc	--	167	87	254	4	25	--	5	12	17	1,368
Minnesota, Wisconsin, etc	--	--	--	--			--	--	--	--	
Oklahoma, Kansas, etc	78	283	707	1,068			8	40	8	56	
Texas inland	73	--	--	73			8	--	--	8	
Texas gulf coast	171	749	1,078	1,998			16	36	182	234	
Louisiana gulf coast	31	1,044	48	1,123	24	407	2	179	14	195	2,852
Arkansas, Louisiana inland, etc	353	--	--	353			1	--	--	1	
New Mexico	--	--	--	--			--	--	--	--	
Rocky Mountain	--	98	--	98	--	--	--	6	--	6	175
West coast	--	574	448	1,022	--	85	--	32	19	51	887
Total	894	3,187	2,927	7,008	652	625	65	322	299	686	7,209

[p]Preliminary.
[1]Conversion factor: 280 pounds = 1 barrel.

Table 38.—Salient statistics of petroleum coke in the United States, by month and refining district

(Thousand barrels unless otherwise indicated)[1]

	1975							1976[P]						
	Production			Yield (percent)	Exports	Stocks, end of period	Domestic demand	Production			Yield (percent)	Exports	Stocks, end of period	Domestic demand
	Marketable	Catalyst	Total					Marketable	Catalyst	Total				
Month:														
January	5,459	5,433	10,892	2.8	3,283	5,384	7,645	5,637	5,366	11,003	2.8	2,606	7,512	8,245
February	5,114	4,711	9,825	2.9	2,803	5,448	6,958	5,236	4,943	10,179	2.7	2,961	7,693	7,037
March	5,492	5,031	10,523	2.9	3,359	5,712	6,900	5,780	5,104	10,884	2.8	2,743	8,023	7,811
April	5,494	4,721	10,215	2.9	2,762	5,955	7,210	5,623	4,883	10,506	2.7	2,678	8,520	7,331
May	5,085	5,070	10,155	2.8	3,334	6,053	6,723	5,835	5,275	11,110	2.7	3,067	8,977	7,586
June	5,419	5,279	10,698	2.9	3,710	6,078	6,963	5,547	5,196	10,743	2.6	3,660	8,926	7,134
July	5,721	5,574	11,295	2.8	2,549	6,415	8,409	5,751	5,452	11,203	2.6	4,404	9,198	6,527
August	5,323	5,667	10,990	2.7	2,968	6,627	7,810	5,782	5,812	11,594	2.7	2,680	9,124	8,988
September	5,613	5,489	11,102	2.8	3,020	7,177	7,532	5,447	5,251	10,698	2.6	2,834	9,333	7,655
October	6,016	5,521	11,537	3.0	2,809	7,386	8,519	5,710	4,965	10,675	2.6	2,962	9,930	7,116
November	5,571	5,006	10,577	2.8	2,607	7,825	7,531	5,570	4,925	10,495	2.5	3,670	10,405	6,350
December	6,193	5,239	11,432	2.9	4,049	7,360	7,848	5,990	5,065	11,055	2.5	3,513	10,636	7,311
Total	66,500	62,741	129,241	2.8	37,253	7,360	90,048	67,908	62,237	130,145	2.6	37,778	10,636	89,091
Refining district:														
East coast	5,200	8,106	13,306	2.8	1,252	3,176	11,215	4,915	8,723	13,638	2.6	981	4,133	12,123
Appalachian No. 1	--	257	257	0.4		--		--	423	423	0.7		--	
Appalachian No. 2	--	253	253	1.2		--		--	268	268	1.2		--	
Indiana, Illinois, Kentucky, etc	10,854	13,142	23,996	3.0	3,296	364	34,827	11,465	12,860	24,325	2.9	2,187	1,664	34,109
Minnesota, Wisconsin, etc	1,594	1,465	3,059	3.5		316		1,820	1,456	3,276	3.5		730	
Oklahoma, Kansas, etc	6,048	5,558	11,606	3.4		419		5,189	5,398	10,587	2.9		865	
Texas inland	438	2,949	3,387	2.1		2		500	2,604	3,104	1.8		4	
Texas gulf coast	9,059	14,306	23,365	2.3		256		9,057	13,776	22,833	2.1		389	
Louisiana gulf coast	8,717	4,728	13,445	2.1	13,668	116	27,134	9,530	5,153	14,683	2.1	15,782	286	25,451
Arkansas, Louisiana inland, etc	397	306	703	1.2		168		416	283	699	1.1		143	
New Mexico	--	200	200	0.8		--		--	194	194	0.7		--	
Rocky Mountain	1,215	2,424	3,639	2.3	2	1,517	3,771	1,341	1,562	2,903	1.8	13	1,371	3,036
West coast	22,978	9,047	32,025	4.5	19,035	1,026	13,101	23,675	9,537	33,212	4.4	18,815	1,051	14,372
Total	66,500	62,741	129,241	2.8	37,253	7,360	90,048	67,908	62,237	130,145	2.6	37,778	10,636	89,091

[P]Preliminary.
[1]Conversion factor: 5.0 barrels = 1 short ton.

Table 39.—Statistical summary of petroleum asphalt and road oil

(Thousand short tons)[1]

	1972	1973	1974	1975	1976^p
Petroleum asphalt:					
Production	28,235	30,524	29,861	26,174	25,401
Imports (including natural)	1,684	1,535	2,046	901	710
Exports	61	62	74	58	49
Stocks, end of period	3,934	2,731	3,885	4,144	3,522
Apparent domestic consumption	29,779	33,200	30,679	26,797	26,684
Petroleum asphalt shipments:					
Paving	24,305	27,041	24,642	21,593	21,475
Roofing	5,347	5,677	4,815	4,803	4,792
All other	1,469	1,615	1,578	1,099	1,033
Total	31,121	34,333	31,035	27,495	27,300
Road oil:					
Production	1,444	1,332	1,302	899	589
Stocks, end of period	237	145	196	104	30
Apparent domestic consumption	1,371	1,424	1,251	991	663
Road oil shipments	1,371	1,424	1,251	991	663

^p Preliminary.
[1]Conversion factor: 5.5 barrels = 1 short ton.

Table 40.—Salient statistics of petroleum asphalt in the United States, by month and refining district

(Thousand short tons)[1]

	1975					1976[p]				
	Production	Imports (including natural)	Exports	Stocks, end of period	Domestic demand	Production	Imports (including natural)	Exports	Stocks, end of period	Domestic demand
Month:										
January	1,488	46	5	4,436	1,017	1,244	74	3	4,535	924
February	1,367	55	3	4,897	958	1,263	30	5	4,917	906
March	1,676	40	6	5,498	1,109	1,571	48	3	5,092	1,441
April	1,711	42	5	5,584	1,662	1,853	38	5	5,212	1,766
May	2,385	95	4	5,746	2,314	2,292	50	5	5,014	2,535
June	2,627	122	6	5,375	3,114	2,703	64	4	4,686	3,090
July	3,021	98	5	5,165	3,323	2,903	61	4	4,389	3,256
August	2,946	143	5	4,777	3,472	2,855	90	4	3,687	3,644
September	2,696	86	4	4,114	3,441	2,762	66	5	3,289	3,222
October	2,630	76	4	3,592	3,224	2,390	69	5	2,988	2,755
November	2,114	55	5	3,669	2,087	2,011	64	3	3,031	2,030
December	1,513	43	6	4,144	1,076	1,554	56	3	3,522	1,115
Total	26,174	901	58	4,144	26,797	25,401	710	49	3,522	26,684
Refining district:										
East coast	4,854	894	8	831	7,106	5,042	681	6	911	6,590
Appalachian No. 1	343			150		276			119	
Appalachian No. 2	255			141		249			106	
Indiana, Illinois, Kentucky, etc	5,430	1	9	924	9,082	5,504	(2)	7	798	10,134
Minnesota, Wisconsin, etc	931			179		1,233			135	
Oklahoma, Kansas, etc	2,476			317		2,396			303	
Texas inland	1,211			100		1,108			123	
Texas gulf coast	1,352			105		1,162			100	
Louisiana gulf coast	2,015	6	21	241	5,213	1,219	29	9	163	4,136
Arkansas, Louisiana inland, etc	1,477			129		1,610			155	
New Mexico	169			49		151			31	
Rocky Mountain	1,774	--	2	433	1,841	1,754	--	7	268	2,049
West coast	3,887	(2)	18	545	3,555	3,697	--	20	310	3,775
Total	26,174	901	58	4,144	26,797	25,401	710	49	3,522	26,684

[p] Preliminary.
[1] Conversion factor: 5.5 barrels = 1 short ton.
[2] Less than 1/2 unit.

Table 41.—Salient statistics of road oil in the United States, by month and refining district

(Short tons)[1]

	1975			1976[p]		
	Production	Stocks, end of period	Domestic demand	Production	Stocks, end of period	Domestic demand
Month:						
January	75,273	228,727	42,909	8,546	103,273	9,091
February	41,636	261,273	9,091	20,909	112,364	11,818
March	47,818	291,273	17,818	23,455	127,273	8,546
April	48,000	304,727	34,546	75,818	187,455	15,636
May	74,000	303,455	75,273	39,455	161,818	65,091
June	160,727	338,000	126,182	73,636	169,091	66,364
July	111,818	151,636	298,182	101,818	158,182	112,727
August	100,364	131,273	120,727	96,727	124,545	130,364
September	69,273	124,909	75,636	60,545	114,545	70,545
October	54,000	122,182	56,727	32,000	69,636	76,909
November	72,909	108,545	86,546	14,727	38,545	45,818
December	43,091	103,818	47,818	41,455	29,818	50,182
Total	898,909	103,818	991,455	589,091	29,818	663,091
Refining district:						
East coast	--	--	1,636	--	--	--
Appalachian No. 1	--	--		--	--	
Appalachian No. 2	--	--		--	--	
Indiana, Illinois, Kentucky, etc	442,182	65,818	523,091	345,455	17,636	474,000
Minnesota, Wisconsin, etc	15,091	--		--	--	
Oklahoma, Kansas, etc	92,545	21,091		60,909	1,637	
Texas inland	4,000	--		182	--	
Texas gulf coast	80,545	--		35,818	--	
Louisiana gulf coast	--	--	84,182	--	--	38,364
Arkansas, Louisiana inland, etc	--	364		2,182	182	
New Mexico	--	--		--	--	
Rocky Mountain	75,091	10,909	67,455	78,000	2,727	79,636
West coast	189,455	5,636	315,091	66,545	7,636	71,091
Total	898,909	103,818	991,455	589,091	29,818	663,091

[p]Preliminary.
[1]Conversion factor: 5.5 barrels = 1 short ton.

Table 42.—Production of miscellaneous finished oils at refineries and natural gas processing plants in the United States in 1976 by refining district and class

(Thousand barrels)

District	Absorption	Petrolatum	Specialty oils[1]	Petrochemicals	Other products[2]	Total
East coast	--	46	788	1,309	201	2,344
Appalachian No. 1	--	206	129	--	3,552	3,887
Appalachian No. 2	--	--	26	2	--	28
Indiana, Illinois, Kentucky, etc	7	35	320	955	13,848	15,165
Minnesota, Wisconsin, North Dakota, South Dakota	--	--	--	134	--	134
Oklahoma, Kansas, etc	129	99	496	--	538	1,262
Texas inland	569	--	706	--	259	1,534
Texas gulf coast	76	921	929	3,995	3,945	9,866
Louisiana gulf coast	129	--	302	6,949	2,464	9,844
Arkansas, Louisiana inland,etc	37	--	107	119	165	428
Rocky Mountain, New Mexico	--	--	4	54	28	86
West coast	19	16	1,179	1,048	370	2,632
Total:						
1976	966	1,323	4,986	14,565	25,370	47,210
1975	1,054	947	5,918	13,189	11,107	32,215

[1]Specialty oils include: Hydraulic, 222; insulating, 274; medicinal, 251; rust preventatives, 2; sand-frac, 702; spray oils, 284; and other, 3,251.
[2]Includes SNG feedstock.

Table 43.—Receipts of domestic and foreign crude petroleum at refineries in the United States

(Million barrels)

Method of transportation	1972	1973	1974	1975	1976[p]
By water:					
Intrastate	155.4	148.9	130.4	134.9	123.8
Interstate	298.5	249.8	211.5	170.2	146.8
Foreign	490.5	775.3	896.1	1,100.9	1,487.4
Total by water	944.4	1,174.0	1,238.0	1,406.0	1,758.0
By pipeline:					
Intrastate	1,832.0	1,796.9	1,692.5	1,641.0	1,622.7
Interstate	1,131.8	1,108.1	1,061.4	1,021.5	1,020.1
Foreign	317.8	408.7	370.7	397.5	443.0
Total by pipeline	3,281.6	3,313.7	3,124.6	3,060.0	3,085.8
By tank cars and trucks:					
Intrastate	47.5	45.7	51.7	56.5	58.4
Interstate	5.7	12.4	22.0	23.7	18.0
Foreign	--	--	--	--	--
Total by tank cars and trucks	53.2	58.1	73.7	80.2	76.4
Grand total	4,279.2	4,545.8	4,436.3	4,546.2	4,920.2

[p]Preliminary.

Table 44.—Interdistrict movement by tanker and barge of crude oil and petroleum products in 1976, by month

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1975 Total
Gulf coast to east coast, total:[1]														
Crude oil	1,688	1,882	2,070	2,476	2,429	1,538	881	1,426	1,316	1,572	1,033	881	19,192	23,794
Unfinished oils	1,136	2,377	1,757	1,055	1,644	566	877	842	2,710	1,231	178	405	14,778	10,938
Gasoline:														
Motor	17,469	16,459	17,919	16,213	15,006	15,221	15,209	17,161	14,877	15,935	14,318	17,949	193,736	186,005
Aviation	159	165	241	200	190	240	234	234	321	131	178	169	2,462	2,746
Total gasoline	17,628	16,624	18,160	16,413	15,196	15,461	15,443	17,395	15,198	16,066	14,496	18,118	196,198	188,751
Special naphthas	661	985	593	650	516	528	658	504	569	810	525	1,075	8,074	7,039
Kerosine	893	992	1,062	923	547	441	981	618	633	927	688	1,158	9,863	8,971
Distillate fuel oil	14,901	13,989	12,741	11,265	7,088	10,551	11,000	8,418	7,832	9,792	11,018	14,012	132,607	124,160
Residual fuel oil	5,169	5,182	5,363	4,920	3,723	3,510	3,210	4,135	3,644	3,338	3,963	3,723	49,880	54,720
Jet fuel:														
Naphtha-type	681	732	1,382	1,157	995	700	1,269	1,120	805	488	492	739	10,560	9,399
Kerosine-type	3,706	2,955	3,878	3,113	3,195	2,786	2,267	3,126	3,061	2,817	3,351	2,536	36,791	36,296
Total jet fuel	4,387	3,687	5,260	4,270	4,190	3,486	3,536	4,246	3,866	3,305	3,843	3,275	47,351	45,695
Lubricating oil	791	1,197	1,038	1,305	1,106	814	1,053	1,265	844	1,214	890	1,035	12,552	10,474
Wax	36	19	24	22	27	14	21	26	41	39	24	18	311	212
Asphalt and road oil	213	179	271	241	370	442	318	389	258	301	295	281	3,558	3,469
Liquefied gases	207	129	373	--	--	--	42	63	18	160	--	231	1,223	1,053
Petrochemical feedstocks	304	484	437	285	229	400	231	298	341	332	44	176	3,561	3,911
Other products	187	276	348	581	178	370	263	282	316	387	301	152	3,641	2,836
Total	48,201	48,002	49,497	44,406	37,243	38,121	38,514	39,907	37,586	39,474	37,298	44,540	502,789	486,023
Gulf coast to PAD district II:														
Crude oil	911	775	979	1,042	969	1,052	1,035	571	684	443	990	834	10,285	13,191
Unfinished oils	--	--	--	--	--	--	67	80	140	--	165	312	764	17
Gasoline:														
Motor	1,898	1,950	5,184	2,133	2,959	2,359	2,985	2,356	2,305	2,651	2,287	2,308	31,375	27,514
Aviation	15	48	54	44	42	95	73	90	34	39	53	20	607	545
Total gasoline	1,913	1,998	5,238	2,177	3,001	2,454	3,058	2,446	2,339	2,690	2,340	2,328	31,982	28,059
Special naphthas	253	226	292	354	324	326	246	277	299	241	368	244	3,450	2,644

See footnotes at end of table.

Table 44.—Interdistrict movement by tanker and barge of crude oil and petroleum products in 1976, by month —Continued

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1975 Total
Gulf coast to PAD district II: —Continued														
Kerosine	133	143	72	103	34	65	199	28	25	131	142	125	1,200	794
Distillate fuel oil	1,200	792	699	585	959	819	1,168	734	758	941	917	1,492	11,064	7,804
Residual fuel oil	581	433	419	445	832	410	614	733	605	616	541	721	6,950	11,721
Jet fuel:														
Naphtha-type	--	--	--	--	--	3	--	--	--	--	--	--	3	162
Kerosine-type	166	524	230	193	230	283	188	375	133	292	351	415	3,380	2,439
Total jet fuel	166	524	230	193	230	286	188	375	133	292	351	415	3,383	2,601
Lubricating oil	191	192	254	368	219	306	395	341	202	362	311	224	3,365	3,015
Wax	--	--	--	--	--	--	--	--	12	--	7	--	19	--
Asphalt and road oil	120	78	68	175	357	350	454	418	327	272	153	188	2,960	2,748
Liquefied gases	3	31	1	--	--	--	--	--	--	25	4	42	106	5
Petrochemical feedstocks	137	169	209	64	146	156	88	92	67	85	117	58	1,388	1,192
Other products	10	41	71	19	76	104	19	79	16	20	20	83	558	275
Total	5,618	5,402	8,532	5,525	7,147	6,328	7,531	6,174	5,607	6,118	6,426	7,066	77,474	74,066
Gulf coast to west coast:														
Motor gasoline	--	--	--	--	613	373	355	234	307	250	220	3	2,355	3,464
Special naphthas	--	25	34	--	--	--	--	--	25	--	10	--	94	13
Distillate fuel oil	40	--	20	--	25	--	--	--	--	--	--	10	95	235
Residual fuel oil	239	499	--	604	1,005	501	--	--	--	--	--	--	2,848	2,500
Jet fuel:														
Naphtha-type	254	--	--	--	--	75	--	--	--	--	--	--	329	159
Kerosine-type	19	--	48	219	234	227	628	201	251	200	229	67	2,323	292
Total jet fuel	273	--	48	219	234	302	628	201	251	200	229	67	2,652	451
Lubricating oil	116	88	174	2	173	17	159	49	53	143	62	261	1,297	1,341
Wax	--	--	--	--	--	--	--	--	15	--	--	--	15	--
Petrochemical feedstocks	--	--	--	--	23	33	--	17	34	--	34	34	175	87
Other products	4	--	5	--	--	--	6	--	--	7	--	5	27	41
Total	672	612	281	825	2,073	1,226	1,148	501	685	600	555	380	9,558	8,132

West coast to east coast:														
Distillate fuel oil	--	--	--	--	--	--	--	--	--	--	160	--	160	--
Lubricating oil	--	--	--	--	--	--	--	--	--	--	--	--	--	220
Other products	--	--	--	--	--	--	--	--	--	--	--	--	--	36
Total	--	--	--	--	--	--	--	--	--	--	160	--	160	256
West coast to gulf coast:														
Distillate fuel oil	--	--	--	--	--	--	--	178	--	--	--	--	178	403
Residual fuel oil	--	--	--	--	--	--	--	--	--	--	--	--	--	822
Lubricating oil	12	--	28	18	--	24	15	24	17	--	10	12	160	--
Unfinished oils	--	--	--	--	--	--	--	--	--	--	506	--	506	--
Total	12	--	28	18	--	24	15	202	17	--	516	12	844	1,225

[1]Breakdown by region shown in table 45.

Table 45.—Tanker and barge movements of crude oil and petroleum products from the gulf coast to the east coast in 1976, by region and month

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total 1976	Total 1975
To New England:														
Gasoline:														
Motor	2,711	2,674	3,926	2,754	2,623	2,243	3,226	2,419	2,741	2,029	2,236	3,132	32,714	27,158
Aviation	31	13	12	19	23	49	45	19	23	37	3	33	307	295
Total gasoline	2,742	2,687	3,938	2,773	2,646	2,292	3,271	2,438	2,764	2,066	2,239	3,165	33,021	27,453
Special naphthas	32	21	16	41	53	9	77	--	83	--	18	84	434	471
Kerosine	218	211	187	208	272	126	93	110	184	110	128	199	2,046	1,666
Distillate fuel oil	5,221	4,490	4,820	3,420	2,506	3,385	3,886	1,638	2,838	1,476	4,190	4,360	42,230	40,686
Residual fuel oil	673	868	535	703	543	388	383	834	1,246	655	589	703	8,120	8,362
Jet fuel:														
Naphtha-type	41	--	293	238	--	--	85	39	177	55	117	7	1,052	591
Kerosine-type	626	366	561	311	482	245	513	408	732	524	516	255	5,539	5,100
Total jet fuel	667	366	854	549	482	245	598	447	909	579	633	262	6,591	5,691
Lubricating oil	10	18	28	193	25	8	29	307	21	19	7	26	691	266
Asphalt and road oil	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Petrochemical feedstocks	--	5	9	10	--	--	8	--	15	--	--	8	55	50
Other products	3	--	11	180	8	--	11	1	11	121	--	1	347	42
Total	9,566	8,666	10,398	8,077	6,535	6,453	8,356	5,775	8,071	5,026	7,804	8,808	93,535	84,687
To Central Atlantic:														
Crude oil	1,688	1,882	2,070	2,476	2,429	1,538	881	1,426	1,316	1,572	1,033	881	19,192	23,696
Unfinished oils	712	2,195	1,184	947	1,477	427	765	691	2,668	1,048	143	299	12,556	9,079
Gasoline:														
Motor	4,973	3,788	4,077	3,487	3,146	3,326	3,392	4,578	3,344	3,502	3,797	4,919	46,329	54,052
Aviation	27	29	71	47	75	29	80	103	120	29	78	42	730	773
Total gasoline	5,000	3,817	4,148	3,534	3,221	3,355	3,472	4,681	3,464	3,531	3,875	4,961	47,059	54,825
Special naphthas	541	808	417	460	294	339	365	340	358	675	330	864	5,791	4,798
Kerosine	263	446	516	498	133	206	602	360	349	448	324	571	4,716	4,972
Distillate fuel oil	7,089	6,968	5,167	4,636	2,289	4,581	4,476	4,387	2,097	5,617	3,699	6,902	57,908	55,823
Residual fuel oil	1,873	2,453	2,345	2,309	1,799	2,359	2,165	2,716	1,909	1,847	2,266	2,363	26,404	24,677

Jet fuel:														
Naphtha-type	56	248	343	100	287	118	239	75	52	--	150	306	1,974	1,081
Kerosine-type	919	451	1,270	605	913	814	620	982	380	981	619	445	8,999	9,558
Total jet fuel	975	699	1,613	705	1,200	932	859	1,057	432	981	769	751	10,973	10,639
Lubricating oil	662	1,055	847	930	908	679	818	787	637	1,070	683	859	9,935	8,407
Wax	14	19	24	22	27	14	21	26	41	39	24	18	289	212
Asphalt and road oil	--	--	--	--	--	24	--	16	55	63	--	--	158	137
Liquefied gases	--	--	321	--	--	--	--	--	--	--	--	--	321	--
Petrochemical feedstocks	267	402	377	211	206	343	190	250	326	305	43	164	3,084	3,636
Other products	84	151	123	327	79	235	184	190	180	207	248	74	2,082	1,383
Total	19,168	20,895	19,152	17,055	14,062	15,032	14,798	16,927	13,832	17,403	13,437	18,707	200,468	202,284
To Lower Atlantic:														
Crude oil	--	--	--	--	--	--	--	--	--	--	--	--	--	98
Unfinished oils	424	182	573	108	167	139	112	151	42	183	35	106	2,222	1,859
Gasoline:														
Motor	9,785	9,997	9,916	9,972	9,237	9,652	8,591	10,164	8,792	10,404	8,285	9,898	114,693	104,795
Aviation	101	123	158	134	92	162	109	112	178	65	97	94	1,425	1,678
Total gasoline	9,886	10,120	10,074	10,106	9,329	9,814	8,700	10,276	8,970	10,469	8,382	9,992	116,118	106,473
Special naphthas	88	156	160	149	169	180	216	164	128	135	177	127	1,849	1,770
Kerosine	412	335	359	217	142	109	286	148	100	369	236	388	3,101	2,333
Distillate fuel oil	2,591	2,531	2,754	3,209	2,293	2,585	2,638	2,393	2,897	2,699	3,129	2,750	32,469	27,651
Residual fuel oil	2,623	1,861	2,483	1,908	1,381	763	662	585	489	836	1,108	657	15,356	21,681
Jet fuel:														
Naphtha-type	584	484	746	819	708	582	945	1,006	576	433	225	426	7,534	7,727
Kerosine-type	2,161	2,138	2,047	2,197	1,800	1,727	1,134	1,736	1,949	1,312	2,216	1,836	22,253	21,638
Total jet fuel	2,745	2,622	2,793	3,016	2,508	2,309	2,079	2,742	2,525	1,745	2,441	2,262	29,787	29,365
Lubricating oil	119	124	163	182	173	127	206	171	186	125	200	150	1,926	1,801
Wax	22	--	--	--	--	--	--	--	--	--	--	--	22	--
Asphalt and road oil	213	179	271	241	370	418	318	373	203	238	295	281	3,400	3,332
Liquefied gases	207	129	52	--	--	--	42	63	18	160	--	231	902	1,053
Petrochemical feedstocks	37	77	51	64	23	57	33	48	--	27	1	4	422	225
Other products	100	125	214	74	91	135	68	91	125	59	53	77	1,212	1,411
Total	19,467	18,441	19,947	19,274	16,646	16,636	15,360	17,205	15,683	17,045	16,057	17,025	208,786	199,052

Table 46.—Transportation of petroleum products by pipeline between PAD districts in the United States in 1976, by month

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total 1976	Total 1975
From district I to district II:														
Gasoline:														
Motor	4,150	3,522	4,170	4,378	4,144	4,400	4,924	4,675	4,270	4,226	3,917	4,441	51,217	48,890
Aviation	4	8	--	--	2	14	5	5	4	--	6	4	52	50
Total gasoline	4,154	3,530	4,170	4,378	4,146	4,414	4,929	4,680	4,274	4,226	3,923	4,445	51,269	48,940
Jet fuel:														
Naphtha-type	19	--	--	--	--	--	--	--	--	--	--	--	19	--
Kerosine-type	181	219	143	70	66	67	86	107	67	178	162	135	1,481	1,590
Total jet fuel	200	219	143	70	66	67	86	107	67	178	162	135	1,500	1,590
Kerosine	40	60	--	10	--	--	--	26	21	24	32	56	269	223
Distillate fuel oil	1,157	1,190	1,105	916	1,038	1,055	1,244	1,125	1,121	1,391	1,340	1,440	14,122	13,440
From district II to district I:														
Gasoline (motor)	936	858	969	932	980	918	680	779	568	1,004	984	1,160	10,768	11,171
Kerosine	34	34	24	--	10	--	--	--	--	--	--	--	102	52
Distillate fuel oil	90	145	90	52	95	59	23	22	49	82	85	199	991	999
Natural gas liquids	377	1,564	1,366	1,202	1,320	1,201	1,103	1,243	1,253	1,015	1,012	1,527	14,183	19,136
From district II to district III:														
Gasoline (motor)	1,992	1,802	2,088	1,810	1,666	1,500	1,666	1,595	1,553	1,601	1,441	1,645	20,359	18,815
Jet fuel:														
Naphtha-type	39	--	80	80	79	79	59	80	27	79	80	41	723	555
Kerosine-type	1	1	1	--	1	1	--	--	--	--	--	--	5	8
Total jet fuel	40	1	81	80	80	80	59	80	27	79	80	41	728	563
Distillate fuel oil	293	633	536	556	538	463	458	582	403	485	539	487	5,973	5,207
Natural gas liquids	605	467	577	561	682	1,004	1,233	1,512	1,473	1,657	1,662	1,702	13,135	4,216
From district II to district IV:														
Gasoline:														
Motor	742	743	864	791	1,229	1,141	1,227	1,138	1,343	1,399	1,210	1,481	13,308	4,169
Aviation	15	16	19	18	19	19	40	54	44	25	17	16	302	--
Total gasoline	757	759	883	809	1,248	1,160	1,267	1,192	1,387	1,424	1,227	1,497	13,610	4,169
Jet fuel (kerosine-type)	342	330	400	309	340	355	749	593	652	599	407	338	5,414	--
Kerosine	1	--	1	2	--	--	--	--	--	--	7	--	11	--

Distillate fuel oil	89	113	131	149	157	150	194	192	195	192	193	122	1,877	460
Natural gas liquids	285	199	182	115	83	61	60	141	153	343	156	279	2,057	--
From district III to district I:														
Gasoline:														
Motor	31,697	27,331	33,500	33,739	32,998	34,452	36,387	33,663	34,322	34,023	31,641	30,561	394,314	353,271
Aviation	19	11	11	5	35	30	42	39	4	9	53	15	273	242
Total gasoline	31,716	27,342	33,511	33,744	33,033	34,482	36,429	33,702	34,326	34,032	31,694	30,576	394,587	353,513
Jet fuel:														
Naphtha-type	119	89	127	114	127	116	116	127	102	128	104	144	1,413	1,318
Kerosine-type	4,314	4,626	4,168	3,988	3,947	4,209	4,555	4,483	4,303	4,012	4,141	4,463	51,209	49,130
Total jet fuel	4,433	4,715	4,295	4,102	4,074	4,325	4,671	4,610	4,405	4,140	4,245	4,607	52,622	50,448
Kerosine	1,845	1,645	1,239	639	201	75	451	756	1,008	938	1,040	1,126	10,963	8,719
Distillate fuel oil	17,663	17,685	16,521	12,725	12,551	13,503	14,406	14,406	13,574	15,004	16,311	19,564	183,913	167,474
Natural gas liquids	2,643	1,690	1,013	666	748	1,155	1,646	1,808	1,570	1,690	2,505	2,664	19,798	17,380
From district III to district II:														
Gasoline:														
Motor	4,596	4,292	4,730	5,437	5,919	6,351	5,837	5,086	4,756	4,997	5,408	6,445	63,854	59,575
Aviation	56	61	86	146	87	98	165	182	185	136	111	103	1,416	1,162
Total gasoline	4,652	4,353	4,816	5,583	6,006	6,449	6,002	5,268	4,941	5,133	5,519	6,548	65,270	60,737
Jet fuel:														
Naphtha-type	--	1	--	--	--	1	--	1	--	2	--	--	5	3
Kerosine-type	383	400	440	363	388	370	962	807	652	1,105	763	912	7,545	1,853
Total jet fuel	383	401	440	363	388	371	962	808	652	1,107	763	912	7,550	1,856
Kerosine	84	55	108	4	5	55	4	117	422	355	53	139	1,401	1,081
Distillate fuel oil	1,519	1,495	590	778	989	1,033	2,046	2,391	1,918	1,754	2,013	3,058	19,584	15,277
Natural gas liquids	9,795	5,819	4,848	6,028	6,764	8,354	7,639	8,724	8,140	5,885	11,260	11,248	94,504	89,201
From district III to district IV:														
Gasoline:														
Motor	--	--	--	--	--	--	--	--	--	--	--	--	--	4,249
Aviation	--	--	--	--	--	--	--	--	--	--	--	--	--	159
Total gasoline	--	--	--	--	--	--	--	--	--	--	--	--	--	4,408
Jet fuel (kerosine-type)	--	--	--	--	--	--	--	--	--	--	--	--	--	3,579
Kerosine	--	--	--	--	--	--	--	--	--	--	--	--	--	4

Table 46.—Transportation of petroleum products by pipeline between PAD districts in the United States in 1976, by month —Continued

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total 1976	Total 1975
From district III to district IV: —Continued														
Distillate fuel oil	--	--	--	--	--	--	--	--	--	--	--	--	--	573
Natural gas liquids	--	--	--	--	--	--	--	--	--	--	--	--	--	1,165
From district III to district V:														
Gasoline (motor)	972	1,044	1,045	1,029	969	861	861	837	761	875	904	834	10,992	11,927
Jet fuel:														
Naphtha-type	--	86	75	90	95	86	109	75	91	79	90	112	988	861
Kerosine-type	127	161	143	98	87	82	102	110	109	77	113	93	1,302	1,150
Total jet fuel	127	247	218	188	182	168	211	185	200	156	203	205	2,290	2,011
Distillate fuel oil	458	377	378	380	418	429	397	496	429	524	415	499	5,200	4,391
From district IV to district II:														
Gasoline (motor)	312	339	398	431	458	561	643	377	499	542	485	420	5,465	5,023
Jet fuel:														
Naphtha-type	28	26	49	39	58	18	28	43	14	24	35	42	404	510
Kerosine-type	4	5	7	9	4	8	5	7	8	8	3	3	71	48
Total jet fuel	32	31	56	48	62	26	33	50	22	32	38	45	475	558
Kerosine	--	--	--	--	--	--	--	--	--	--	--	--	--	17
Distillate fuel oil	273	217	284	244	384	375	332	110	316	324	276	336	3,471	3,591
Natural gas liquids	--	--	--	100	--	--	--	--	--	--	--	--	100	--
From district IV to district III:														
Natural gas liquids	--	--	11	--	--	--	--	--	--	--	--	--	11	3,391
From district IV to district V:														
Gasoline (motor)	189	911	1,026	883	951	826	840	802	792	601	712	929	9,462	10,346
Jet fuel:														
Naphtha-type	--	61	83	69	70	58	65	68	71	79	76	85	785	776
Kerosine-type	--	80	99	54	98	93	105	81	84	68	61	34	857	603
Total jet fuel	--	141	182	123	168	151	170	149	155	147	137	119	1,642	1,379
Distillate fuel oil	31	216	234	291	340	117	264	270	330	401	343	391	3,228	4,329

Table 47.—Transportation of petroleum products by pipelines in the United States in 1976, by month

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total 1976	Total 1975
Turned into lines:														
Gasoline:														
Motor	152,140	147,121	161,113	158,389	172,281	179,529	179,616	177,758	163,747	168,794	165,254	173,041	1,998,783	1,818,994
Aviation	128	292	331	406	356	388	426	564	413	475	384	261	4,424	3,836
Total gasoline	152,268	147,413	161,444	158,795	172,637	179,917	180,042	178,322	164,160	169,269	165,638	173,302	2,003,207	1,822,830
Jet fuel:														
Naphtha-type	4,250	3,674	4,099	3,650	4,037	3,607	3,652	3,266	2,918	3,314	3,354	3,197	43,018	34,040
Kerosine-type	24,054	21,682	24,459	22,098	22,799	22,700	24,720	23,532	25,097	21,839	22,477	24,758	280,215	225,538
Total jet fuel	28,304	25,356	28,558	25,748	26,836	26,307	28,372	26,798	28,015	25,153	25,831	27,955	323,233	259,578
Kerosine	4,488	4,418	2,720	1,703	1,323	1,245	1,506	1,751	2,005	2,801	2,734	3,705	30,399	30,864
Distillate fuel oil	68,975	64,355	58,388	54,493	56,162	52,653	58,407	59,086	57,237	63,944	71,158	80,477	745,335	667,058
Residual fuel oil	496	162	241	212	158	214	203	161	185	210	211	208	2,661	--
Natural gas liquids	47,388	42,728	41,201	42,567	44,080	46,391	44,256	45,859	44,723	48,543	66,118	53,216	567,070	504,714
Special naphthas	--	--	--	--	--	--	271	44	--	--	--	--	315	--
Delivered from lines:														
Gasoline:														
Motor	155,362	145,716	161,478	159,476	171,148	179,052	181,632	178,499	166,195	170,841	165,592	171,512	2,006,503	1,817,210
Aviation	225	243	299	310	409	397	403	537	438	361	438	280	4,340	3,850
Total gasoline	155,587	145,959	161,777	159,786	171,557	179,449	182,035	179,036	166,633	171,202	166,030	171,792	2,010,843	1,821,060
Jet fuel:														
Naphtha-type	3,678	3,624	4,186	3,957	3,699	3,782	3,645	3,292	3,027	3,185	3,270	3,261	42,606	34,127
Kerosine-type	23,635	21,684	23,655	21,560	22,055	22,420	24,733	23,542	24,008	21,980	22,704	23,781	275,757	221,991
Total jet fuel	27,313	25,308	27,841	25,517	25,754	26,202	28,378	26,834	27,035	25,165	25,974	27,042	318,363	256,118
Kerosine	4,291	4,431	3,021	1,976	1,090	1,395	1,211	1,454	2,013	2,328	2,695	3,485	29,390	29,686
Distillate fuel oil	72,135	68,460	63,051	55,036	55,642	51,019	55,829	56,931	55,878	65,212	69,738	82,098	751,029	668,037
Residual fuel oil	496	162	241	212	158	214	203	161	185	210	211	208	2,661	--
Natural gas liquids	49,045	40,765	40,724	42,772	44,135	45,008	44,668	43,410	44,495	47,880	49,203	57,436	549,541	497,288
Special naphthas	--	--	--	--	--	--	271	44	--	--	--	--	315	--

See footnotes at end of table.

Table 47.—Transportation of petroleum products by pipelines in the United States in 1976, by month —Continued

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total 1976	Total 1975
Shortage or overage:[1]														
Gasoline:														
Motor	(25)	(622)	(921)	(1,026)	(7)	(475)	(744)	(836)	(780)	(687)	(134)	(968)	(7,225)	(1,340)
Aviation	(4)	(1)	24	8	36	9	3	36	4	11	25	(6)	145	82
Total gasoline	(29)	(623)	(897)	(1,018)	29	(466)	(741)	(800)	(776)	(676)	(109)	(974)	(7,080)	(1,258)
Jet fuel:														
Naphtha-type	8	(31)	9	3	(22)	3	(11)	(37)	26	(7)	(24)	7	(76)	21
Kerosine-type	274	229	371	289	447	321	324	239	294	308	285	288	3,669	3,234
Total jet fuel	282	198	380	292	425	324	313	202	320	301	261	295	3,593	3,255
Kerosine	178	91	235	11	66	54	40	83	52	131	19	158	1,118	1,228
Distillate fuel oil	(447)	(71)	(419)	(366)	471	205	(113)	(153)	(250)	(138)	(469)	(849)	(2,599)	(571)
Natural gas liquids	32	529	758	544	344	511	388	781	746	361	134	715	5,843	7,070
Stocks in lines and working tanks at end of month:														
Gasoline:														
Motor	45,148	47,175	47,731	47,670	48,810	49,762	48,490	48,585	46,917	45,557	45,353	47,850	47,850	48,345
Aviation	64	114	122	210	121	103	123	114	85	188	109	96	96	157
Total gasoline	45,212	47,289	47,853	47,880	48,931	49,865	48,613	48,699	47,002	45,745	45,462	47,946	47,946	48,502
Jet fuel:														
Naphtha-type	1,352	1,433	1,337	1,027	1,387	1,209	1,227	1,238	1,103	1,239	1,347	1,276	1,276	788
Kerosine-type	5,776	5,545	5,978	6,227	6,524	6,483	6,146	5,897	6,692	6,243	5,731	6,420	6,420	5,631
Total jet fuel	7,128	6,978	7,315	7,254	7,911	7,692	7,373	7,135	7,795	7,482	7,078	7,696	7,696	6,419
Kerosine	1,841	1,737	1,201	917	1,084	880	1,135	1,349	1,289	1,631	1,651	1,713	1,713	1,822
Distillate fuel oil	29,994	25,960	21,716	21,539	21,588	23,017	25,708	28,016	29,625	28,495	30,384	29,612	29,612	32,707
Natural gas liquids	19,244	20,678	20,397	19,648	19,249	20,121	19,321	20,989	20,471	20,773	37,554	32,619	32,619	20,933

[1] Figures in parenthesis denote shortage.

Table 48.—Pipeline tariff rates for crude petroleum and petroleum products, January 1

(Cents per barrel)

Origin	Destination	1976	1977
Crude oil:			
West Texas	Houston, Tex	28	30
Do	East Chicago, Ind	39	42
Do	Wood River, Ill	39	42
Oklahoma	Chicago, Ill	29	34
Do	Wood River, Ill	21	25
Eastern Wyoming	Chicago, Ill	38	42
Do	Wood River, Ill	35	39
Refined products:			
Houston Tex	Atlanta, Ga	58	59
Do	New York, N.Y	52	52
Tulsa, Okla	Minneapolis, Minn	85	89
Salt Lake City, Utah	Spokane, Wash	52	54
Philadelphia, Pa	Rochester, N.Y	50	60

Source: Interstate Commerce Commission.

Table 49.—Stocks of crude petroleum, natural gas liquids, and refined products in the United States at yearend

(Thousand barrels)

	1972	1973	1974	1975	1976
Crude petroleum:					
At refineries	70,327	76,971	83,214	86,761	95,574
Pipeline and tank farm	162,476	152,533	168,944	172,610	171,709
Producers	13,592	12,974	12,862	11,983	18,188
Total crude petroleum	246,395	242,478	265,020	271,354	285,471
Unfinished oils	94,761	99,154	106,031	106,352	110,488
Natural gasoline[1]	4,802	6,160	6,480	6,217	6,649
Plant condensate	1,273	1,675	1,070	1,165	1,479
Refined products	611,748	658,840	695,045	747,867	707,723
Grand total	958,979	1,008,307	1,073,646	1,132,955	1,111,810

[1]Includes isopentane.

Table 50.—Stocks of crude petroleum in the United States in 1976, by State of origin and month

(Thousand barrels)

State of origin	Jan. 1	Jan. 31	Feb. 29	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Alabama	375	269	242	468	901	333	430	438	271	331	281	617	387
Alaska	4,502	4,060	4,004	3,559	2,501	2,261	2,963	2,874	2,850	2,529	3,351	3,223	3,619
Arizona	86	82	86	75	77	90	64	78	74	81	80	85	68
Arkansas	1,440	684	758	881	301	818	743	641	600	675	677	674	780
California	23,727	24,217	23,721	24,384	23,162	22,652	21,529	21,384	22,078	20,840	22,864	23,766	22,256
Colorado	2,911	2,822	2,468	2,863	3,211	2,987	2,744	2,669	2,396	2,462	2,787	2,783	2,492
Florida	3,149	3,492	3,058	3,030	3,215	3,540	3,170	2,867	2,635	2,800	3,157	3,536	3,562
Illinois	3,517	2,723	3,587	3,076	2,870	3,030	2,974	2,785	2,960	2,932	2,798	3,478	2,996
Indiana	712	598	583	568	552	372	431	390	445	410	381	425	429
Kansas	5,421	5,438	5,395	5,807	5,761	5,973	4,774	5,361	4,683	4,671	4,802	5,118	5,230
Kentucky	890	281	396	920	320	414	382	341	167	330	671	307	294
Louisiana	26,952	28,883	27,988	26,973	29,159	28,042	28,124	27,603	26,251	28,807	30,550	27,390	26,404
Michigan	1,783	1,674	1,793	1,815	1,768	1,825	2,105	2,161	2,035	2,218	2,178	1,977	1,979
Mississippi	2,323	2,375	2,867	2,569	2,522	2,495	2,195	2,188	2,029	2,193	2,488	2,376	2,379
Missouri	4	1	1	1	1	1	1	1	3	3	1	1	1
Montana	2,314	2,580	2,758	2,726	2,658	3,052	2,671	2,799	2,611	2,483	2,976	2,867	2,813
Nebraska	1,015	952	843	945	1,066	1,248	1,183	1,091	1,210	1,262	1,416	1,425	1,575
Nevada	--	--	--	--	--	--	--	--	--	--	--	--	1
New Mexico	8,137	8,229	8,329	8,625	8,537	8,989	7,872	8,474	7,676	8,649	7,971	8,112	7,801
New York	38	11	8	8	8	10	12	13	8	7	11	8	7
North Dakota	1,680	1,562	1,395	1,362	1,257	1,284	1,710	1,298	1,428	1,452	1,499	1,473	1,444
Ohio	1,274	1,203	775	1,105	1,100	1,347	1,166	1,167	1,164	1,065	1,067	1,008	879
Oklahoma	15,309	17,605	16,776	16,172	15,572	16,990	15,472	14,891	14,841	13,991	16,088	16,217	14,831
Pennsylvania	564	501	488	675	665	562	478	558	576	469	471	378	270
South Dakota	1	2	2	3	2	2	2	2	2	3	9	1	2
Tennessee	--	6	12	8	11	5	6	13	11	5	1	4	1
Texas	91,883	102,685	98,772	100,438	99,378	98,456	100,150	99,329	99,476	100,073	105,740	103,679	99,398
Utah	3,888	3,680	3,441	3,556	3,976	3,729	3,310	3,330	2,987	2,591	2,655	2,832	2,406
West Virginia	711	478	483	509	525	478	357	357	350	429	414	387	367
Wyoming	19,065	20,130	19,285	20,197	21,245	22,085	18,492	17,756	16,323	16,329	16,395	17,897	18,854
Total domestic crude	223,671	237,223	230,314	233,318	232,321	233,070	225,510	222,859	218,140	220,090	233,779	232,044	223,525
Foreign crude:													
Districts I-IV	34,255	39,031	35,998	36,719	39,904	36,636	40,861	43,656	45,180	51,529	48,807	50,232	47,094
District V	13,428	13,042	11,102	13,075	14,403	14,276	15,344	16,084	13,952	12,738	15,097	16,560	14,852
Total foreign crude	47,683	52,073	47,100	49,794	54,307	50,912	56,205	59,740	59,132	64,267	63,904	66,792	61,946
Total crude stocks	271,354	289,296	277,414	283,112	286,628	283,982	281,715	282,599	277,272	284,357	297,683	298,836	285,471
Pennsylvania-grade crude oil (includedin "Total domestic crude")	2,176	1,666	1,493	1,882	1,874	2,010	1,564	1,697	1,732	1,494	1,511	1,423	1,112

Table 51.—Stocks of crude petroleum in the United States in 1976, by State and month

(Thousand barrels)

State	Jan. 1	Jan. 31	Feb. 29	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Alabama	1,488	1,631	1,257	1,657	2,483	1,559	2,167	1,784	1,793	1,998	2,186	1,910	2,173
Alaska, Arizona, Hawaii, Nevada, Oregon, Washington	6,864	6,773	7,416	7,459	7,204	5,792	7,486	7,191	6,658	6,898	7,759	6,872	6,874
Arkansas	1,996	1,572	1,553	1,622	950	1,533	1,389	1,321	1,265	1,364	1,411	1,387	1,533
California	36,069	36,068	33,088	35,111	34,873	34,891	33,561	34,311	33,230	30,087	34,439	37,557	34,739
Colorado	1,647	1,662	1,587	1,800	1,893	1,918	1,716	1,659	1,490	1,524	1,542	1,601	1,473
Delaware and Maryland	964	1,462	1,719	1,839	1,676	1,656	960	1,186	1,251	1,856	906	1,188	1,445
Florida, Georgia, Virginia, West Virginia	2,112	2,241	2,411	2,111	2,146	2,161	2,043	2,166	2,089	2,082	2,343	2,202	2,535
Illinois	19,842	20,277	19,868	20,614	19,050	20,833	17,273	17,330	19,440	18,919	20,159	19,809	20,508
Indiana	3,809	3,738	3,510	3,465	3,344	3,301	3,579	3,559	3,812	3,848	3,894	3,930	3,902
Iowa, Missouri, Nebraska	7,408	7,942	8,087	8,240	7,836	7,964	7,730	7,609	7,664	7,633	7,886	8,179	7,817
Kansas	10,447	11,093	11,239	11,501	11,424	10,804	10,738	10,142	10,082	10,320	10,348	10,341	10,208
Kentucky and Tennessee	4,276	3,319	3,202	2,797	2,027	3,401	2,985	2,971	2,179	1,429	2,286	2,970	2,956
Louisiana	21,365	22,960	21,352	20,769	23,673	22,655	23,352	22,937	21,993	28,158	27,368	23,589	25,162
Michigan	2,566	2,904	2,976	2,823	3,040	3,505	3,828	2,903	3,034	3,012	2,698	3,044	2,937
Minnesota and Wisconsin	3,509	3,406	3,196	3,321	3,390	3,429	2,795	3,229	3,100	3,069	3,107	3,794	3,488
Mississippi	4,601	3,876	4,051	5,046	3,527	3,931	4,242	3,784	3,303	4,281	5,008	4,398	3,893
Montana	3,103	2,728	2,772	2,840	2,846	3,144	2,862	2,498	2,456	2,530	2,832	2,937	2,849
New Hampshire, New York, Rhode Island	1,127	1,297	1,559	1,499	1,497	1,619	1,225	1,859	2,256	1,871	1,433	1,763	1,895
New Jersey	5,086	6,361	4,908	5,750	6,029	5,702	6,579	6,198	5,494	5,345	4,806	5,430	4,197
New Mexico	3,865	4,744	4,755	4,847	5,038	5,073	4,961	4,844	5,238	5,014	5,127	5,098	5,159
North Dakota and South Dakota	1,304	1,199	1,131	1,172	1,111	1,213	1,165	1,159	1,157	1,188	1,232	1,185	1,176
Ohio	7,978	6,798	6,183	6,506	6,415	6,505	6,600	6,967	6,027	6,474	6,871	7,188	6,610
Oklahoma	21,905	24,072	21,499	22,132	21,425	23,326	22,286	20,443	20,646	20,887	23,464	25,169	23,472
Pennsylvania	6,582	6,791	7,217	6,409	7,765	5,097	7,831	8,979	7,851	8,070	7,646	7,790	5,183
Texas	79,542	92,430	88,385	88,739	92,397	88,936	90,372	94,595	93,608	96,751	100,445	97,742	91,011
Utah	1,568	1,642	1,691	1,600	1,702	1,860	1,551	1,770	1,666	1,520	1,626	1,701	1,575
Wyoming	10,331	10,310	10,802	11,443	11,867	12,174	10,439	9,205	8,490	8,229	8,861	10,062	10,701
Total	271,354	289,296	277,414	283,112	286,628	283,982	281,715	282,599	277,272	284,357	297,683	298,836	285,471

Table 52.—Stocks of crude petroleum in the United States in 1976, by classification, State, and month

(Thousand barrels)

Classification and State	Jan. 1	Jan. 31	Feb. 29	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
At refineries:													
Alabama	256	232	263	364	334	310	532	250	442	516	452	600	554
Alaska, Arizona, Hawaii, Nevada, Oregon, Washington	4,918	4,814	4,732	5,226	5,410	4,475	5,181	5,531	4,707	5,433	5,547	5,095	5,252
Arkansas	96	172	185	199	221	226	221	189	164	237	137	143	151
California	19,675	19,686	17,346	18,838	19,280	19,946	19,857	20,660	18,956	16,378	20,763	22,357	20,269
Colorado	239	353	343	295	394	504	380	377	357	328	265	367	254
Delaware and Maryland	964	1,462	1,719	1,839	1,676	1,656	960	1,186	1,251	1,856	906	1,188	1,445
Florida, Georgia, Virginia, West Virginia	1,239	1,737	1,603	1,458	1,486	1,472	1,458	1,451	1,439	1,329	1,547	1,647	1,774
Illinois	5,092	5,399	4,971	5,056	4,670	5,267	4,678	4,871	5,183	4,803	5,108	4,824	5,167
Indiana	1,408	1,250	1,085	1,151	1,095	1,227	1,203	1,239	1,349	1,198	1,204	1,102	1,217
Iowa, Missouri, Nebraska	327	337	317	345	2,081	283	312	316	322	304	351	416	440
Kansas	1,607	1,639	1,812	1,982	1,158	1,984	1,678	1,767	1,722	1,731	1,716	1,824	1,931
Kentucky and Tennessee	960	1,198	852	1,092	807	1,283	1,169	1,113	797	779	740	1,252	1,013
Louisiana	8,956	10,291	9,188	9,168	10,070	10,017	10,505	10,332	9,785	14,142	13,750	11,453	13,202
Michigan	1,018	856	913	809	1,236	874	1,085	901	931	963	876	932	959
Minnesota and Wisconsin	1,549	1,245	1,596	1,327	303	1,271	1,285	1,234	1,345	1,367	1,210	1,311	1,208
Mississippi	1,287	1,058	1,241	1,645	1,251	1,449	1,724	1,821	1,242	2,260	2,609	1,596	1,816
Montana	585	785	951	918	1,001	997	967	704	759	679	836	911	927
New Hampshire, New York, Rhode Island	889	806	825	735	838	687	669	1,055	1,463	1,153	684	800	834
New Jersey	5,086	6,361	4,908	5,750	6,029	5,702	6,579	6,198	5,494	5,345	4,806	5,430	4,197
New Mexico	493	469	455	556	552	517	642	574	607	502	494	543	631
North Dakota and South Dakota	266	276	284	233	169	284	228	248	260	333	383	333	280
Ohio	2,109	1,914	1,917	2,128	2,031	1,990	2,152	2,267	1,831	2,051	2,135	2,198	2,300
Oklahoma	1,765	1,861	1,851	1,728	2,018	1,983	1,791	1,782	1,829	1,863	1,988	2,018	1,803
Pennsylvania	5,669	6,076	6,405	5,555	6,976	4,568	7,227	8,144	7,162	7,506	6,786	7,331	4,616
Texas	18,551	20,863	18,373	19,456	23,450	20,162	21,178	23,970	23,261	26,028	26,152	25,689	21,796
Utah	643	640	592	536	551	701	561	566	614	579	593	577	577
Wyoming	1,114	1,065	1,084	1,090	1,225	1,262	1,123	1,253	1,152	1,088	1,140	1,181	961
Total at refineries	86,761	92,845	85,811	89,479	96,312	91,097	95,345	99,999	94,424	100,751	103,178	103,118	95,574
Pipeline and tank farm stocks:													
Alabama	1,205	1,369	971	1,266	2,123	1,220	1,607	1,503	1,320	1,451	1,701	1,276	1,587
Alaska, Arizona, Hawaii, Nevada, Oregon, Washington	1,889	1,903	2,624	2,167	1,727	1,245	2,206	1,597	1,892	1,417	2,160	1,721	1,568
Arkansas	1,829	1,353	1,289	1,207	680	1,255	1,091	1,079	1,048	1,064	1,219	1,202	1,330

California	15,169	15,109	14,478	14,975	14,247	13,494	12,415	12,341	12,918	12,326	12,363	13,962	13,021
Colorado	1,209	1,192	1,112	1,376	1,368	1,281	1,206	1,136	992	1,048	1,127	1,089	1,063
Florida, Georgia, Virginia West Virginia	658	451	755	576	619	638	532	655	596	690	751	503	711
Illinois	14,680	14,796	14,808	15,475	14,295	15,476	12,513	12,376	14,176	14,037	14,964	14,900	15,259
Indiana	2,348	2,485	2,422	2,310	2,246	2,071	2,372	2,316	2,459	2,647	2,687	2,825	2,681
Iowa, Missouri, Nebraska	6,977	7,578	7,740	7,868	9,099	7,658	7,393	7,266	7,312	7,301	7,504	7,735	7,348
Kansas	8,653	9,225	9,183	9,282	863	8,574	8,828	8,130	8,124	8,351	8,390	8,308	8,039
Kentucky and Tennessee	3,269	2,115	2,344	1,699	2,134	2,111	1,810	1,853	1,376	645	1,539	1,711	1,938
Louisiana	10,209	10,428	10,037	9,519	11,607	10,507	10,774	10,422	10,113	11,938	11,475	10,040	9,961
Michigan	1,423	1,940	1,955	1,900	2,154	2,522	2,645	1,897	1,998	1,950	1,716	1,997	1,860
Minnesota and Wisconsin	1,960	2,161	1,600	1,994	7,507	2,158	1,510	1,995	1,755	1,702	1,897	2,483	2,280
Mississippi	3,127	2,628	2,623	3,202	2,105	2,299	2,342	1,788	1,883	1,851	2,214	2,628	1,913
Montana	2,192	1,654	1,532	1,610	1,533	1,825	1,563	1,454	1,382	1,533	1,680	1,699	1,618
New Hampshire, New York, Rhode Island	208	491	734	764	659	932	556	804	793	718	749	898	1,061
New Mexico	2,578	2,811	2,727	2,763	2,967	3,003	2,778	2,712	2,973	3,006	3,053	2,913	2,970
North Dakota and South Dakota	968	851	771	874	874	866	873	852	837	795	786	805	836
Ohio	5,794	4,827	4,211	4,330	4,335	4,478	4,394	4,640	4,145	4,370	4,684	4,941	4,260
Oklahoma	19,240	21,514	18,964	19,648	18,644	20,606	19,785	17,953	18,104	18,313	20,744	22,469	20,987
Pennsylvania	820	696	792	836	770	509	586	816	671	547	840	441	549
Texas	56,743	61,932	59,512	59,050	58,628	58,210	58,857	60,175	59,772	60,461	63,170	61,078	58,684
Utah	747	734	824	804	880	878	721	927	790	668	769	865	799
Wyoming	8,715	8,902	9,337	10,009	10,282	10,535	8,956	7,604	6,985	6,795	7,361	8,538	9,386
Total at pipelines and tank farms	172,610	179,145	173,345	175,504	172,346	174,351	168,313	164,291	164,414	165,624	175,543	177,027	171,709
Lease stocks	11,983	17,306	18,258	18,129	17,970	18,534	18,057	18,309	18,434	17,982	18,962	18,691	18,188
Total stocks:													
1976	271,354	289,296	277,414	283,112	286,628	283,982	281,715	282,599	277,272	284,357	297,683	298,836	285,471
1975	265,020	270,462	276,755	279,989	281,908	280,961	276,132	264,157	256,616	259,446	269,584	270,950	271,354

Table 53.—Stocks of refined petroleum products (including unfinished oils) in the United States at end of month

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1975												
Gasoline:												
Motor	242,340	251,974	248,749	232,619	213,997	207,155	212,504	215,512	226,478	221,532	232,139	234,978
Aviation	3,602	3,462	3,345	3,048	3,031	2,859	2,737	2,863	2,757	2,922	3,140	3,024
Total gasoline	245,942	255,436	252,094	235,667	217,028	210,014	215,241	218,375	229,235	224,454	235,279	238,002
Jet fuel:												
Naphtha-type	5,548	5,415	6,155	5,777	5,484	5,253	5,578	5,654	5,797	5,864	5,812	5,222
Kerosine-type	24,773	23,718	24,301	24,486	25,235	24,084	24,220	25,449	25,494	24,546	23,165	25,158
Total Jet fuel	30,321	29,133	30,456	30,263	30,719	29,337	29,798	31,103	31,291	30,410	28,977	30,380
Ethane (including ethylene)	4,709	4,969	5,390	5,619	6,130	7,080	7,330	7,317	6,778	6,389	6,725	7,014
Liquefied gases[1]	98,062	93,509	91,738	95,775	105,539	117,033	123,914	131,152	134,845	134,183	131,358	118,134
Kerosine	16,466	15,348	15,170	15,255	16,512	15,351	16,038	17,153	17,775	17,772	18,237	15,571
Distillate fuel oil	199,752	176,734	161,149	146,257	152,070	163,348	181,514	197,364	220,776	226,160	235,798	208,833
Residual fuel oil	69,233	66,495	64,148	66,340	73,498	69,660	71,526	71,857	76,938	81,858	83,131	74,126
Petrochemical feedstocks	3,888	3,459	3,308	3,475	3,047	2,847	2,651	2,705	3,025	2,739	2,987	2,924
Special naphthas	5,535	5,317	5,606	5,173	5,046	5,000	4,469	4,360	4,481	4,302	4,366	4,377
Lubricants	15,659	15,543	16,486	16,045	15,406	14,896	14,725	14,159	13,981	13,343	14,178	14,337
Wax	1,088	1,014	969	976	947	959	951	912	807	743	817	861
Coke	5,384	5,448	5,712	5,955	6,053	6,078	6,415	6,627	7,177	7,386	7,825	7,360
Asphalt	24,399	26,932	30,238	30,713	31,603	29,561	28,410	26,274	22,626	19,755	20,179	22,794
Road oil	1,258	1,437	1,602	1,676	1,669	1,859	834	722	687	672	597	571
Miscellaneous	1,699	1,902	1,849	1,998	1,982	2,057	2,103	2,109	2,870	2,935	2,628	2,583
Unfinished oils	97,488	99,182	103,345	107,071	113,922	111,605	108,580	110,759	107,374	106,327	108,767	106,352
Total 1975	820,883	801,858	789,260	768,258	781,171	786,685	814,499	842,948	880,666	879,428	901,849	854,219
1976												
Gasoline:												
Motor	240,510	248,901	239,097	224,008	225,079	225,408	226,961	230,614	229,793	226,355	227,787	231,432
Aviation	2,869	2,856	2,796	2,552	2,437	2,335	2,483	2,601	2,815	2,716	2,751	2,840
Total gasoline	243,379	251,757	241,893	226,560	227,516	227,743	229,444	233,215	232,608	229,071	230,538	234,272
Jet fuel:												
Naphtha-type	6,143	6,151	5,724	5,765	6,671	6,365	6,079	6,333	5,910	6,991	6,809	6,495
Kerosine-type	24,475	25,029	26,895	27,567	27,993	27,514	26,653	26,788	27,294	27,041	27,050	25,590
Total jet fuel	30,618	31,180	32,619	33,332	34,664	33,879	32,732	33,121	33,204	34,032	33,859	32,085

Ethane (including ethylene)	7,483	8,579	8,669	9,192	9,428	9,853	10,663	11,160	11,594	11,855	12,770	13,600
Liquefied gases[1]	101,538	96,945	99,852	104,791	112,880	120,508	127,750	132,455	135,598	132,044	121,469	102,695
Kerosine	11,906	11,379	11,744	11,748	12,914	13,051	13,403	14,951	15,178	15,626	14,404	12,514
Distillate fuel oil	165,477	150,472	138,340	137,285	147,097	165,110	190,900	217,969	232,268	235,638	223,685	185,986
Residual fuel oil	66,592	68,859	65,132	66,458	65,147	64,272	69,812	68,490	76,436	79,117	73,284	72,344
Petrochemical feedstocks	3,277	3,211	3,440	3,143	3,450	3,267	3,667	3,887	4,884	4,902	4,782	4,714
Special naphthas	4,582	4,438	4,311	4,112	3,919	3,737	3,732	3,831	3,703	3,993	4,129	4,441
Lubricants	14,629	13,980	12,982	12,459	12,718	12,404	11,832	12,164	12,103	12,146	12,318	12,274
Wax	824	730	683	693	719	749	703	784	723	706	704	686
Coke	7,512	7,693	8,023	8,520	8,977	8,926	9,198	9,124	9,333	9,930	10,405	10,636
Asphalt	24,944	27,046	28,007	28,664	27,576	25,772	24,142	20,281	18,091	16,432	16,669	19,375
Road oil	568	618	700	1,031	890	930	870	685	630	383	212	164
Miscellaneous	2,263	2,476	2,092	1,949	1,897	1,656	1,680	1,741	1,942	1,976	2,223	1,937
Unfinished oils	106,164	105,708	110,020	111,447	110,431	111,150	112,739	107,580	109,737	109,661	111,445	110,488
Total 1976	791,756	785,071	768,507	761,384	780,223	803,007	843,267	871,438	898,032	897,512	872,896	818,211

[1]Includes LRG used for petrochemical feedstocks.

Table 54.—Value of crude petroleum at wells in the United States, by State

State	1975 Total value at wells (thousands)	1975 Average value per barrel	1976 Total value at wells (thousands)	1976 Average value per barrel
Alabama	$136,541	$10.13	$155,437	$10.57
Alaska	364,630	5.22	318,789	5.03
Arizona	3,332	5.25	2,724	5.25
Arkansas	143,336	8.88	174,636	9.65
California	1,943,048	6.03	2,005,577	6.15
Colorado	365,654	9.60	376,273	9.65
Florida	490,258	11.71	499,573	11.24
Illinois	273,182	10.48	267,449	10.18
Indiana	48,821	10.54	50,421	10.89
Kansas	561,508	9.50	557,783	9.50
Kentucky	84,520	11.19	85,454	11.42
Louisiana:				
Gulf coast	4,358,452	7.10	4,275,314	7.52
Northern	253,427	6.79	281,447	7.36
Total or average Louisiana	4,611,879	7.09	4,556,761	7.51
Michigan	262,352	10.74	329,637	7.14
Mississippi	310,346	6.66	328,957	7.14
Montana	257,169	7.83	276,419	8.42
Nebraska	55,133	9.01	55,551	8.99
New Mexico:				
Southeastern	734,204	8.29	761,397	8.84
Northwestern	53.869	8.29	53,022	8.84
Total or average New Mexico	788,073	8.29	814,419	8.84
New York	10,693	12.22	10,397	12.25
North Dakota	149,705	7.32	170,411	7.84
Ohio	113,917	11.89	117,655	11.77
Oklahoma	1,389,164	8.52	1,484,197	9.19
Pennsylvania	39,647	12.15	36,700	12,16
South Dakota	5,996	12.70	5,519	12.35
Tennessee	7,849	11.51	8,203	13.72
Texas:				
Gulf coast	1,866,358	7.96		
East Texas field	533,269	7.73		
West Texas	4,925,842	7.47	[1]10,217,702	[1]8.59
Panhandle	159,887	7.76		
Rest of State	1,851,214	7.76		
Total or average Texas	9,336,570	7.64	10,217,702	8.59
Utah	348,131	8.23	318,911	9.30
West Virginia	29,712	11.99	30,227	12.00
Wyoming	983,785	7.24	971,235	7.24
Other States[2]	1,108	6.33	2,323	11.22
Total or average United States	23,116,059	7.56	24,229,540	8.14

[1]Not individually available for 1976.
[2]Missouri, Nevada and Virginia.

Table 55.—Posted price per barrel of petroleum at wells in the United States in 1976, by grade, with date of price change[1]

(Dollars)

Grade	January	March	April	May	June-December[2]
Pennsylvania grade:					
Bradford and Allegheny districts	6.83	6.83 (11.12)	6.83 (11.19)	6.93 (11.26)	6.96 (11.32)
Southwest Pennsylvania	6.12	6.12 (10.60)	6.12 (10.67)	6.22 (11.74)	6.25 (11.80)
Corning grade	5.17	5.17 (10.97)	5.17 (11.04)	5.12 (11.11)	5.15 (11.17)
Western Kentucky	5.20	5.20	5.26 (11.22)	5.26 (11.11)	5.33 (11.55)
Indiana-Illinois	5.20	5.20	5.26 (11.42)	5.30 (11.49)	5.35 (11.55)
Coldwater, Mich	5.00	5.02	5.08 (11.67)	5.12 (11.74)	5.15 (11.80)
Oklahoma-Kansas:					
34°-34.9° API	5.11	5.14 (11.50	--	--	--
36°-36.9° API	5.15	5.18 (11.80)	--	--	--
Texas, Panhandle (Carson, Gray, Hutchinson, Wheeler Counties), 35°-35.9° API	5.10	5.13	5.18 (11.69)	5.20 (11.74)	5.23 (11.80)
West Texas, 30°-30.9° API (sweet)	5.11	5.14 (11.50)	5.21 (12.07)	5.18 (12.07)	5.24 (12.10)
Lea County, New Mexico, 30°-30.9° API (sour)	5.00	5.03 (11.15)	5.06 (11.22)	5.10 (11.29)	5.15 (11.35)
South Texas, Mirando, 24°-24.9° API	5.30	5.33 (11.80)	5.26 (11.67)	5.30 (11.84)	5.35 (11.90)
East Texas	5.20	5.20	5.26 (11.67)	5.30 (11.74)	5.33 (11.80)
Conroe, Texas	5.30	5.30	5.36 (11.77)	5.40 (11.84)	5.43 (11.90)
Texas:					
30°-30.9° API	5.05	5.08	--	--	--
20°-20.9° API	4.95	4.98	--	--	--
Louisiana, 30°-30.9° API	5.15	5.18 (11.40)	--	--	--
Caddo-Pine Island, La., North, 36°-36.9° API	5.04	5.07 (11.32)	5.10 (11.39)	5.14 (10.46)	5.17 (11.52)
Bay Marchand, La., South, 36°-36.9° API	5.27	5.27	5.33 (11.59)	5.37 (11.66)	5.40 (11.72)
Alaska Cook inlet 36°-39° API	4.71	4.71	4.77 (10.43)	4.87 (10.50)	4.84 (10.56)
Magnolia Smackover, Limestone, Arkansas, 31°-31.9° API	4.84	4.74	4.80 (10.99)	4.84 (11.06)	4.87 (11.12)
Elk Basin, Wyo. (including Montana), 30°30.9° API	4.88	4.88	4.94 (11.37)	11.98 (11.44)	5.01 (11.50)
California:					
Coalinga, 32°-32.9° API	5.01	5.15 (10.09)	5.18 (10.16)	5.22 (10.23)	5.25 (10.29)
Kettlemen Hills, 37°-37.9° API	5.26	5.34 (10.54)	5.37 (10.61)	5.41 (10.68)	5.44 (10.74)
Midway Sunset, 19°-19.9° API	4.28	4.38 (9.60)	4.41 (9.67)	4.45 (9.74)	4.48 (8.01)
Wilmington, 24°-24.9° API	4.63	4.73 (9.80)	4.76 (9.87)	4.80 (9.94)	4.83 (10.00)

[1]The lower value figures (at the left) are lower level prices. The higher numbers in (parenthesis) are the corresponding upper level prices.
[2]Prices were frozen at June 1976 levels by the Federal Energy Administration.

Table 56.—Wholesale price index for crude petroleum

(1967 = 100)

Month	1972	1973	1974	1975	1976
January	113.2	114.7	178.4	223.1	263.2
February	113.2	114.7	201.7	228.6	242.3
March	113.2	114.9	201.7	230.2	242.4
April	113.2	117.1	201.7	232.2	245.3
May	113.2	122.0	201.7	234.2	246.1
June	113.2	125.3	201.7	256.0	247.8
July	113.2	125.8	224.4	250.4	254.3
August	114.7	125.8	225.2	256.1	254.3
September	114.7	133.3	225.4	256.1	254.3
October	114.7	133.3	226.2	257.8	264.4
November	114.7	139.3	231.0	261.0	264.4
December	114.7	146.2	223.0	262.6	264.4
Average	113.8	126.0	211.8	245.6	253.6

Source: Bureau of Labor Statistics, U.S. Department of Labor.

Table 57.—Average monthly price of petroleum products in the United States, 1975-76

Monthly average and grade	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average for year
Gasoline, 92 octane, cents per gallon:														
At refineries in Oklahoma	1975	27.50	27.50	27.50	27.25	28.70	30.83	33.36	35.25	34.90	34.50	34.39	33.05	31.23
	1976	32.38	32.01	31.61	31.93	33.79	35.47	36.00	35.79	35.49	35.17	35.13	35.13	34.16
Tank wagon prices to dealers at 55 cities on first of month	1975	32.07	32.09	32.56	33.24	34.41	35.60	36.88	38.64	38.64	38.64	38.38	38.16	35.78
	1976	37.86	37.11	36.61	36.76	37.57	39.12	40.12	40.68	40.75	40.75	40.28	40.28	38.99
At service station (including all taxes)	1975	53.98	53.94	54.18	54.50	55.55	56.91	59.17	59.83	59.83	59.87	59.42	59.42	57.22
	1976	58.65	58.06	57.42	57.01	57.97	59.75	60.37	60.94	61.01	61.01	60.85	60.61	59.47
Kerosine, cents per gallon:														
No.1 range at Chicago district	1975	29.87	29.75	29.75	29.75	30.40	30.95	31.75	31.86	32.00	32.95	32.13	33.62	31.32
	1976	32.43	31.74	31.74	31.23	31.44	32.22	32.50	32.50	32.49	32.45	33.27	34.89	32.38
No. 1 fuel oil at Oklahoma	1975	27.00	26.75	26.75	26.25	27.23	27.73	28.88	29.13	29.13	29.75	29.75	30.31	28.22
	1976	30.50	30.63	30.25	29.88	30.02	30.76	31.29	31.38	31.55	31.67	32.43	33.31	31.14
Kerosine (or No. 1 fuel oil) at New York Harbor	1975	28.83	28.83	29.89	30.71	30.49	30.25	30.25	30.42	31.25	32.76	33.80	33.77	30.94
	1976	33.45	33.45	32.71	35.53	32.62	33.03	33.03	33.16	34.35	33.45	33.93	34.98	33.39
Kerosine (or No. 1 fuel oil) at Miami	1975	28.35	28.35	29.28	29.91	30.03	30.03	30.03	30.26	31.08	32.00	32.33	32.83	30.37
	1976	32.83	32.83	32.83	32.83	32.83	32.83	32.83	32.83	32.83	32.83	33.46	34.41	33.01
Distillate and diesel fuel oil, cents per gallon:														
No. 2 fuel oil at refineries, Oklahoma	1975	26.00	25.75	25.75	25.25	26.23	26.73	27.88	28.13	28.13	28.75	28.75	29.31	27.22
	1976	29.50	29.63	29.25	28.88	29.02	29.76	30.29	30.38	30.55	30.67	31.43	32.31	30.14
No. 2 fuel oil at New York Harbor	1975	27.39	27.39	28.35	29.16	28.98	28.80	28.80	28.99	29.89	30.55	30.90	31.37	29.21
	1976	31.70	31.70	30.09	29.54	30.77	31.50	31.50	31.33	31.48	31.77	32.48	33.83	31.47
Marine diesel, dollars per barrel:														
New York Harbor	1975	14.99	14.99	14.99	14.99	14.99	14.99	14.99	14.99	14.99	14.99	14.99	14.99	14.99
	1976	15.48	14.98	14.98	14.98	14.98	14.98	14.98	14.87	14.95	14.98	14.98	14.98	15.01
New Orleans	1975	15.12	15.12	15.12	15.12	15.12	15.12	15.12	15.12	15.12	15.12	15.12	15.12	15.12
	1976	15.48	14.98	14.98	14.98	14.98	14.98	14.94	14.73	14.73	14.73	14.73	14.73	14.92
San Francisco marine diesel[1]	1975	15.68	15.68	15.68	15.68	15.68	15.68	15.68	15.68	15.68	15.68	15.68	15.68	15.68
Residual fuel oil, dollars per barrel:														
No. 6 fuel at refineries, Oklahoma	1975	8.85	8.85	8.85	8.85	8.85	8.85	8.85	8.85	8.45	8.00	8.00	8.00	8.60
	1976	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.25	8.19	9.32	9.96	8.31
N0. 6 fuel oil at New York Harbor (Maximum 0.3% sulfur)	1975	13.76	13.76	13.76	13.81	13.67	13.58	13.51	13.46	12.94	12.81	12.81	12.87	13.39
	1976	13.05	13.39	13.46	13.46	13.06	13.06	13.04	12.96	13.16	13.44	13.64	14.15	13.32
Bunker "C" for ships, dollars per barrel:														
New York	1975	11.09	11.33	11.56	11.56	11.56	11.68	11.73	11.25	11.13	11.11	10.79	10.58	11.28
	1976	11.48	11.38	11.10	11.10	11.10	11.10	11.11	11.23	11.43	11.85	11.85	11.85	11.38

New Orleans	1975	10.50	10.72	10.63	10.45	10.63	11.09	11.37	11.12	11.07	11.06	10.90	10.94	10.87
	1976	10.98	11.13	10.60	10.60	10.60	10.60	10.57	10.20	10.20	10.20	10.20	10.20	10.51
San Francisco	1975	10.05	10.05	10.22	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.48
	1976	10.05	10.05	10.05	10.05	10.26	10.30	10.32	10.68	10.68	10.68	10.68	10.68	10.37
Lubricating oil, cents per gallon:														
East Coast:														
200 viscosity at 100° F, 0-10 pour test, 95 V.I	1975	46.75	46.75	46.75	46.75	46.75	46.75	46.75	46.75	46.75	46.75	46.75	46.75	46.75
	1976	47.64	49.25	49.25	49.25	49.25	49.25	49.25	50.34	52.00	52.00	52.00	52.61	50.17
500 viscosity at 100° F, 0-10 pour test, 95 V.I	1975	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50	50.50
	1976	50.94	51.75	51.75	51.75	51.75	51.75	51.75	52.55	54.50	54.50	54.50	54.96	52.70
South Texas:														
500 viscosity No. 2 1/2 - 3 1/2 color	1975	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	41.50	42.30	42.50	41.65
	1976	42.50	42.50	42.50	42.50	42.50	42.50	42.00	42.44	43.50	43.50	43.50	45.11	42.90
Liquefied petroleum gas (propane), cents per barrel:														
New York Harbor	1975	17.74	17.74	17.74	19.81	20.74	20.74	21.09	21.74	22.20	22.74	23.24	23.24	20.73
	1976	23.24	23.65	23.71	22.40	22.40	21.97	22.56	22.74	22.97	23.74	24.57	24.74	23.23
Oklahoma	1975	13.50	13.50	13.50	13.93	14.79	15.79	15.98	16.82	16.89	17.17	17.86	17.96	15.64
	1976	18.10	18.21	17.98	17.68	17.71	18.71	18.05	17.69	19.13	19.13	19.18	19.58	18.43
Baton Rouge	1975	16.64	16.64	16.64	17.21	16.98	16.62	17.84	19.17	19.53	19.65	20.68	20.75	18.19
	1976	20.77	19.75	19.75	19.75	19.75	20.14	20.42	20.50	20.97	20.97	21.71	22.13	20.55

[1]Not published in 1976 edition.

Source: Platt's Oil Price Handbook and Oilmanac.

Table 58.—Petroleum oils, crude and refined, exported from the United States, including shipments to territories and possessions by month[1]

(Thousand barrels)

Year and class	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1975													
Crude petroleum	836	942	349	19	--	--	--	--	--	--	--	--	2,146
Refined products:													
Gasoline:[2]													
Motor	17	266	26	38	14	22	39	13	5	32	27	245	744
Aviation	9	4	3	5	8	11	9	6	5	10	5	31	106
Total gasoline	26	270	29	43	22	33	48	19	10	42	32	276	850
Jet fuel:													
Naphtha-type	--	--	--	--	--	--	--	--	--	--	--	--	--
Kerosine-type	59	62	43	39	68	39	69	52	45	44	41	49	610
Total jet fuel	59	62	43	39	68	39	69	52	45	44	41	49	610
Liquefied gases:													
Butane	429	384	550	424	381	315	315	368	365	384	327	394	4,636
Propane	496	463	439	446	403	352	398	373	343	384	327	428	4,852
Total liquefied gases	925	847	989	870	784	667	713	741	708	768	654	822	9,488
Kerosine	3	2	--	12	1	6	2	4	--	12	4	6	52
Distillate fuel oil	2	50	1	51	7	48	11	49	1	1	10	36	267
Residual fuel oil	463	528	295	178	246	619	540	371	577	164	376	985	5,342
Petrochemical feedstocks	377	406	696	839	549	627	638	1,139	893	528	478	867	8,037
Special naphthas	140	151	55	47	118	94	103	90	112	104	72	135	1,221
Lubricants	820	767	587	686	955	740	860	710	652	1,060	558	716	9,111
Wax	30	28	70	33	77	40	71	47	58	64	41	48	607
Coke	3,283	2,803	3,359	2,762	3,334	3,710	2,549	2,968	3,020	2,809	2,607	4,049	37,253
Asphalt	27	19	31	27	21	35	29	29	22	21	28	31	320
Miscellaneous	79	69	102	107	93	75	123	70	61	179	76	90	1,124
Total refined	6,234	6,002	6,257	5,694	6,275	6,733	5,756	6,289	6,159	5,796	4,977	8,110	74,282
Total crude and refined	7,070	6,944	6,606	5,713	6,275	6,733	5,756	6,289	6,159	5,796	4,977	8,110	76,428

1976[P]													
Crude petroleum	--	--	45	--	1	--	--	380	--	563	900	1,052	2,941
Refined products:													
Gasoline:[2]													
Motor	6	179	199	225	35	14	41	209	12	2	15	206	1,143
Aviation	10	26	39	14	4	5	8	14	22	4	4	4	154
Total gasoline	16	205	238	239	39	19	49	223	34	6	19	210	1,297
Jet fuel:													
Naphtha-type	--	--	--	--	--	--	--	--	--	--	--	--	--
Kerosine-type	89	115	52	48	45	39	56	55	56	63	89	59	766
Total jet fuel	89	115	52	48	45	39	56	55	56	63	89	59	766
Liquefied gases:													
Butane	341	312	358	354	325	403	374	335	307	359	372	387	4,227
Propane	409	353	447	430	372	438	366	330	320	396	401	504	4,766
Total liquefied gases	750	665	805	784	697	841	740	665	627	755	773	891	8,993
Kerosine	9	1	4	2	2	1	4	4	8	2	--	3	40
Distillate fuel oil	7	24	35	15	21	26	15	125	38	28	43	44	421
Residual fuel oil	416	865	312	532	313	210	332	245	253	153	465	114	4,210
Petrochemical feedstocks	265	989	493	909	336	603	789	622	839	380	3,375	1,544	11,144
Special naphthas	105	98	244	294	141	141	131	926	112	104	70	144	2,510
Lubricants	451	877	619	981	741	721	797	753	899	921	857	878	9,495
Wax	37	67	33	66	41	30	65	52	52	46	50	86	625
Coke	2,606	2,961	2,743	2,678	3,067	3,660	4,404	2,680	2,834	2,962	3,670	3,513	37,778
Asphalt	16	28	16	28	26	24	24	18	26	29	16	16	267
Miscellaneous	62	102	86	84	92	68	111	72	99	119	107	110	1,112
Total refined	4,829	6,997	5,680	6,660	5,561	6,383	7,517	6,440	5,877	5,568	9,534	7,612	78,658
Total crude and refined	4,829	6,997	5,725	6,660	5,562	6,383	7,517	6,820	5,877	6,131	10,434	8,664	81,599

[P]Preliminary.
[1]Compiled from records of U. S. Department of Commerce.
[2]Includes benzol, natural gasoline, and antiknock compounds.

Table 59.—Crude oil and petroleum products exported from the United States, by country of destination

(Thousand barrels)

Country of destination	Crude oil	Gasoline	Special naphthas	Jet fuel	Kerosine	Distillate fuel oil	Residual fuel oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
1975															
North America:															
Canada	19	12	274	133	8	6	948	1,224	77	42	65	4,588	464	298	8,158
Mexico	--	49	107	187	1	35	4,001	431	113	9,188	138	1,072	43	60	15,425
Total	19	61	381	320	9	41	4,949	1,655	190	9,230	203	5,660	507	358	23,583
Central America and Caribbean:															
Bahamas	--	5	4	--	(1)	2	20	32	1	1	(1)	--	1	(1)	66
British West Indies	--	--	(1)	--	--	(1)	--	2	4	--	--	--	(1)	(1)	6
Jamaica	--	--	8	--	(1)	(1)	--	182	1	(1)	1	1	2	4	199
Netherlands Antilles	--	--	4	--	--	--	--	18	(1)	--	1	--	(1)	1	24
Panama	--	--	1	--	(1)	--	1	33	1	--	3	--	2	2	43
Puerto Rico	--	434	58	--	--	2	194	272	3	6	18	301	601	41	1,930
Trinidad	--	--	(1)	--	--	--	--	34	1	--	(1)	--	4	3	42
Virgin Islands	2,127	170	2	--	26	8	155	33	1	59	--	--	--	--	2,581
Others	--	(1)	30	--	--	1	5	228	3	6	49	--	14	14	350
Total	2,127	609	107	--	26	13	375	834	15	72	72	302	624	65	5,241
South America:															
Argentina	--	--	16	4	(1)	--	1	260	(1)	--	5	134	1	1	422
Brazil	--	--	61	--	1	--	7	1,264	5	--	3	356	403	127	2,227
Chile	--	--	1	--	--	--	1	120	1	--	5	--	1	7	136
Ecuador	--	--	3	--	--	--	--	22	1	--	11	1	4	5	47
Peru	--	--	1	--	--	--	2	84	(1)	3	5	--	1	8	104
Venezuela	--	(1)	25	--	(1)	--	(1)	32	29	1	17	140	5	40	289
Others	--	(1)	2	--	--	--	(1)	138	(1)	1	4	(1)	6	10	161
Total	--	(1)	109	4	1	--	11	1,920	36	5	50	631	421	198	3,386
Europe:															
Belgium	--	--	40	--	--	--	--	516	2	--	2	2,615	8	24	3,207
Denmark	--	--	(1)	--	--	1	--	8	(1)	(1)	3	1	1	1	15

France	--	(1)	13	--	--	(1)	(1)	93	(1)	--	14	650	1,241	1	2,012
Greece	--	2	1	--	--	--	--	13	--	--	1	172	1	(1)	190
Ireland	--	--	(1)	--	--	--	--	7	--	--	1	(1)	--	(1)	8
Italy	--	10	21	--	(1)	--	1	206	2	(1	6	2,724	774	4	3,748
Netherlands	--	(1)	200	--	--	44	(1)	244	(1)	(1)	14	7,073	767	25	8,367
Norway	--	(1)	--	--	--	--	--	11	6	(1)	(1)	1,108	--	1	1,126
Spain	--	--	(1)	--	--	--	(1)	33	(1)	(1)	6	719	577	12	1,347
Sweden	--	--	(1)	--	--	--	(1)	103	1	1	4	281	189	5	584
United Kingdom	--	19	80	--	--	--	(1)	472	3	--	5	486	1,565	6	2,636
West Germany	--	--	2	--	--	(1)	1	205	2	(1)	117	2,933	146	13	3,419
Yugoslavia	--	--	(1)	--	--	--	(1)	4	--	(1)	--	318	--	--	322
Others	--	(1)	3	--	--	--	(1)	43	1	(1)	2	437	8	7	501
Total	--	31	360	--	(1)	45	2	1,958	17	1	175	19,517	5,277	99	27,482
Middle East:															
Bahrain	--	(1)	(1)	--	(1)	--	--	4	(1)	--	(1)	166	--	1	171
Iran	--	--	1	(1)	--	(1)	--	59	1	--	(1)	107	1	2	171
Israel	--	--	1	--	--	--	1	21	(1)	2	1	(1)	3	1	30
Saudi Arabia	--	--	1	--	--	4	1	191	2	--	(1)	--	4	2	205
Turkey	--	--	--	--	--	--	--	46	(1)	--	(1)	52	105	16	219
Others	--	(1)	18	1	(1)	--	2	91	35	1	12	1	13	25	199
Total	--	(1)	21	1	(1)	4	4	412	38	3	13	326	126	47	995
Africa:															
Egypt	--	(1)	(1)	--	--	--	--	121	(1)	--	(1)	--	39	(1)	160
Ghana	--	--	1	--	--	--	--	59	(1)	--	(1)	385	1	(1)	446
Nigeria	--	--	1	--	--	--	--	56	1	(1)	5	--	2	17	82
South Africa, Republic of	--	--	9	--	(1)	--	--	160	3	2	37	64	562	48	885
Tunisia	--	--	--	--	--	--	--	(1)	--	--	--	--	(1)	--	(1)
Others	--	--	16	--	(1)	--	(1)	134	4	166	9	239	11	27	606
Total	--	(1)	27	--	(1)	--	(1)	530	8	168	51	688	615	92	2,179

See footnotes at end of table.

Table 59.—Crude oil and petroleum products exported from the United States, by country of destination —Continued

(Thousand barrels)

Country of destination	Crude oil	Gasoline	Special naphthas	Jet fuel	Kerosine	Distillate fuel oil	Residual fuel oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
1975 —Continued															
Asia and Oceania:															
Australia	--	(1)	66	--	4	--	1	133	10	6	9	378	223	55	885
French Pacific Islands	--	73	--	--	9	--	--	6	--	--	--	--	--	(1)	88
India	--	--	(1)	--	--	--	(1)	346	(1)	(1)	5	--	(1)	3	354
Indonesia	--	(1)	1	--	--	--	--	117	1	2	1	--	9	3	134
Japan	--	4	76	--	(1)	1	(1)	537	3	1	18	9,225	26	121	10,012
Malaysia	--	--	20	--	--	--	--	46	(1)	--	(1)	--	(1)	(1)	66
New Zealand	--	(1)	12	--	--	--	(1)	29	--	--	1	240	3	39	324
Philippines	--	(1)	31	--	--	--	(1)	133	1	--	6	--	200	25	396
South Vietnam	--	(1)	2	--	--	--	--	(1)	--	--	--	--	(1)	(1)	(1)
Taiwan	--	--	8	--	--	--	(1)	105	(1)	--	2	--	3	19	137
Thailand	--	(1)	2	--	--	--	--	44	--	--	1	35	3	--	85
U.S. Pacific Islands[2]	--	72	(1)	285	2	163	--	11	1	--	(1)	--	(1)	--	534
Others	--	--	(1)	--	1	--	--	295	--	--	--	251	(1)	(1)	547
Total	--	149	216	285	16	164	1	1,802	16	9	43	10,129	467	265	13,562
Total exports	2,146	850	1,221	610	52	267	5,342	9,111	320	9,488	607	37,253	8,037	1,124	76,428
1976[p]															
North America:															
Canada	2,241	28	407	39	1	64	1,278	1,123	81	187	68	4,077	469	274	10,337
Mexico	--	83	102	237	(1)	1	1,884	227	96	8,744	113	1,110	32	48	12,677
Total	2,241	111	509	276	1	65	3,162	1,350	177	8,931	181	5,187	501	322	23,014
Central America and Caribbean:															
Bahamas	--	6	4	--	--	1	2	35	3	(1)	(1)	--	1	(1)	52
British West Indies	--	--	(1)	--	--	1	--	7	1	3	(1)	--	(1)	(1)	12
Jamaica	--	--	6	--	(1)	--	--	173	--	(1)	1	(1)	15	5	200
Netherlands Antilles	--	--	(1)	--	--	1	--	28	2	(1)	2	--	1	(1)	34
Panama	--	--	2	--	(1)	--	--	41	(1)	(1)	2	--	4	2	51
Puerto Rico	655	852	812	39	1	3	438	308	7	31	22	383	4,260	19	7,830
Trinidad	45	20	(1)	--	--	--	--	42	(1)	(1)	(1)	--	8	2	117

Virgin Islands	--	143	1	--	8	51	--	38	4	2	([1])	--	1	([1])	248
Others	--	--	42	([1])	([1])	2	509	287	6	5	34	--	27	16	928
Total	700	1,021	867	39	9	59	949	959	23	41	61	383	4,317	44	9,472
South America:															
Argentina	--	--	3	--	--	--	--	179	--	([1])	2	135	1	1	321
Brazil	--	--	110	--	--	--	1	1,197	([1])	2	10	95	992	48	2,455
Chile	--	([1])	([1])	--	--	--	2	135	([1])	1	6	1	3	7	155
Ecuador	--	--	6	--	--	--	--	21	2	--	4	--	4	5	42
Peru	--	--	1	--	--	--	--	79	([1])	([1])	2	([1])	1	5	88
Venezuela	--	([1])	33	--	([1])	([1])	([1])	41	2	1	13	126	2	24	242
Others	--	--	11	--	--	--	--	109	18	--	2	--	8	23	171
Total	--	([1])	164	--	([1])	([1])	3	1,761	22	4	39	357	1,011	113	3,474
Europe:															
Belgium	--	1	109	--	--	--	([1])	668	4	--	2	3,502	20	50	4,356
Denmark	--	--	([1])	--	--	--	--	10	([1])	1	3	30	1	([1])	45
France	--	1	61	--	([1])	--	([1])	184	([1])	--	17	865	1,177	4	2,309
Greece	--	([1])	3	--	([1])	--	--	19	([1])	([1])	([1])	395	1	([1])	418
Ireland	--	--	([1])	--	--	--	--	10	--	--	([1])	--	([1])	([1])	10
Italy	--	([1])	17	--	([1])	([1])	([1])	212	2	1	6	2,354	943	2	3,537
Netherlands	--	([1])	233	--	13	([1])	([1])	230	([1])	1	8	7,109	493	25	8,112
Norway	--	--	--	--	--	--	--	15	2	1	([1])	961	1	2	982
Spain	--	--	10	--	--	--	([1])	54	([1])	--	23	906	539	14	1,546
Sweden	--	--	([1])	--	--	--	([1])	63	--	--	--	--	143	2	208
United Kingdom	--	1	176	--	1	--	1	469	5	--	4	844	1,207	24	2,732
West Germany	--	([1])	12	--	--	1	1	236	3	--	178	4,120	91	43	4,685
Yugoslavia	--	--	--	--	--	--	--	4	([1])	--	--	--	([1])	--	4
Others	--	12	14	71	([1])	--	69	94	2	([1])	3	670	67	6	1,008
Total	--	15	635	71	14	1	71	2,268	18	4	244	21,756	4,683	172	29,952

See footnotes at end of table.

Table 59.—Crude oil and petroleum products exported from the United States, by country of destination —Continued

(Thousand barrels)

Country of destination	Crude oil	Gaso-line	Special naph-thas	Jet fuel	Kero-sine	Distil-late fuel oil	Resid-ual fuel oil	Lubri-cating oil	As-phalt	Lique-fied petro-leum gases	Wax	Coke	Petro-chemi-cal feed-stocks	Miscel-laneous prod-ucts	Total
1976[p] —Continued															
Middle East:															
Bahrain	--	--	(1)	--	--	--	--	3	(1)	--	--	356	(1)	1	360
Iran	--	(1)	1	--	--	--	(1)	100	1	--	--	129	11	1	243
Israel	--	(1)	1	--	--	(1)	(1)	25	(1)	1	(1)	--	2	3	32
Saudi Arabia	--	--	3	--	--	(1)	1	302	2	3	(1)	(1)	7	12	330
Turkey	--	--	(1)	--	--	--	--	167	(1)	--	(1)	--	117	25	309
Others	--	--	--	--	--	--	--	--	5	1	--	--	--	--	6
Total	--	(1)	5	--	--	(1)	1	597	8	5	(1)	485	137	42	1,280
Africa:															
Egypt	--	--	(1)	--	--	--	--	116	1	--	(1)	--	1	1	119
Ghana	--	(1)	(1)	--	--	--	--	65	(1)	--	(1)	333	2	1	401
Nigeria	--	(1)	(1)	--	--	--	--	54	2	(1)	1	--	4	17	78
South Africa, Republic of	--	(1)	39	--	(1)	(1)	1	108	(1)	1	32	23	343	65	612
Tunisia	--	--	--	--	--	--	--	(1)	--	--	--	--	(1)	--	(1)
Others	--	(1)	3	--	--	(1)	--	114	2	1	3	(1)	7	16	146
Total	--	(1)	42	--	(1)	(1)	1	457	5	2	36	356	357	100	1,356
Asia and Oceania:															
Australia	--	--	42	--	3	1	2	159	5	5	5	405	63	53	743
French Pacific Islands	--	--	(1)	--	--	--	--	4	--	--	--	--	--	--	4
India	--	--	(1)	--	--	--	--	254	(1)	--	1	--	(1)	9	264
Indonesia	--	--	3	--	--	--	1	102	(1)	--	1	--	7	6	120
Japan	--	39	135	--	3	22	17	732	6	--	38	8,184	37	113	9,326
Malaysia	--	--	18	--	--	--	--	36	(1)	--	--	--	(1)	(1)	54
New Zealand	--	(1)	7	--	--	--	1	16	(1)	(1)	1	394	(1)	39	458
Philippines	--	(1)	17	--	--	(1)	--	193	1	(1)	8	--	5	24	248
South Vietnam	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Taiwan	--	(1)	25	--	--	1	1	163	1	--	3	70	3	30	297
Thailand	--	--	5	--	--	--	--	60	(1)	(1)	1	--	5	9	80
U.S. Pacific Islands[2]	--	44	(1)	380	--	272	--	8	(1)	--	--	--	--	--	704
Others	--	67	36	--	10	--	1	376	1	1	6	201	18	36	753

Total	--	150	288	380	16	296	23	2,103	14	6	64	9,254	138	319	13,051
Total exports	2,941	1,297	2,510	766	40	421	4,210	9,495	267	8,993	625	37,778	11,144	1,112	81,599

[p]Preliminary.
[1]Less than 1/2 unit.
[2]Data reported to the Bureau of Mines by shippers.

Table 60.—Crude oil, refined products, plant condensate, and unfinished oils imported in the United States, by month[1]

(Thousand barrels)

Year and class	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1975													
Crude petroleum	124,901	107,194	113,345	101,338	108,072	117,142	129,966	142,016	140,675	136,068	138,703	138,761	1,498,181
Petroleum products:													
Motor gasoline	8,115	4,784	4,645	3,989	4,398	5,304	6,475	7,184	8,077	6,417	4,180	3,681	67,249
Jet fuel:													
Naphtha-type	730	984	947	413	713	650	490	861	1,420	818	998	1,315	10,339
Kerosine-type	6,381	4,604	3,073	3,709	3,424	2,523	2,230	3,240	2,782	2,473	1,669	2,076	38,184
Total jet fuel	7,111	5,588	4,020	4,122	4,137	3,173	2,720	4,101	4,202	3,291	2,667	3,391	48,523
Liquefied gases:													
Butane	2,052	1,281	1,542	1,884	535	1,472	1,214	1,218	1,582	1,807	2,015	2,067	18,669
Propane	3,486	1,956	1,420	1,169	644	1,304	1,828	1,315	2,040	2,501	1,885	2,510	22,058
Total liquefied gases	5,538	3,237	2,962	3,053	1,179	2,776	3,042	2,533	3,622	4,308	3,900	4,577	40,727
Kerosine	299	234	107	--	42	--	--	80	15	98	141	57	1,073
Distillate fuel oil	10,355	8,453	7,911	3,297	4,225	2,072	3,219	2,854	3,885	3,232	2,894	4,281	56,678
Residual fuel oil	51,374	39,269	40,074	31,618	35,965	27,071	34,863	31,641	39,322	38,792	36,762	39,777	446,528
Petrochemical feedstocks	974	--	93	--	100	336	--	380	--	--	--	178	2,061
Special naphthas	--	30	1	1	1	--	2	1	2	2	1	2	43
Lubricants	90	184	137	150	1	71	137	81	67	202	106	109	1,335
Wax	55	78	58	114	4	33	57	8	62	87	64	64	684
Asphalt	253	303	217	233	522	672	539	787	471	418	302	239	4,956
Miscellaneous	264	418	186	246	320	36	43	--	266	235	43	283	2,340
Plant condensate	2,430	1,836	2,544	2,231	1,828	2,212	2,311	2,514	2,646	1,842	1,971	2,607	26,972
Unfinished oils	921	1,323	1,330	817	841	1,291	1,354	1,066	816	1,212	836	1,178	12,985
Total petroleum products	87,779	65,737	64,285	49,871	53,563	45,047	54,762	53,230	63,453	60,136	53,867	60,424	712,154
Total crude and products	212,680	172,931	177,630	151,209	161,635	162,189	184,728	195,246	204,128	196,204	192,570	199,185	2,210,335

1976[p]													
Crude petroleum	142,427	122,030	146,879	143,687	144,748	168,641	179,540	172,221	176,237	176,679	178,367	183,686	1,935,142
Petroleum products:													
Motor gasoline	2,850	2,427	3,806	2,980	3,461	5,631	5,883	4,384	5,119	4,264	4,379	2,590	47,774
Jet fuel:													
Naphtha-type	323	642	164	357	906	445	529	271	336	469	485	587	5,514
Kerosine-type	1,815	1,416	2,496	2,894	2,369	1,600	3,511	900	1,549	1,085	1,185	1,649	22,469
Total jet fuel	2,138	2,058	2,660	3,251	3,275	2,045	4,040	1,171	1,885	1,554	1,670	2,236	27,983
Liquefied gases:													
Butane	1,973	2,286	2,027	1,169	1,804	1,816	1,165	2,027	1,571	2,202	2,400	2,228	22,668
Propane	2,851	1,854	1,859	1,382	969	1,609	1,579	1,326	1,637	3,140	2,915	3,647	24,768
Total liquefied gases	4,824	4,140	3,886	2,551	2,773	3,425	2,744	3,353	3,208	5,342	5,315	5,875	47,436
Kerosine	8	368	264	251	61	237	97	178	253	487	328	631	3,163
Distillate fuel oil	5,074	6,011	4,671	2,875	2,993	4,517	3,917	4,059	4,408	4,371	4,039	5,535	52,470
Residual fuel oil	43,600	49,401	41,610	37,728	35,151	37,188	45,316	40,510	43,269	38,246	44,232	55,514	511,765
Petrochemical feedstocks	581	233	--	93	--	286	--	177	--	--	--	--	1,370
Special naphthas	2	1	2	3	2	3	3	3	8	5	5	8	45
Lubricants	162	45	73	77	163	60	79	92	289	28	171	122	1,361
Wax	61	32	62	63	88	47	62	65	38	9	64	61	652
Asphalt	407	167	262	207	274	351	337	494	366	378	355	307	3,905
Miscellaneous	290	55	17	25	38	23	35	45	47	--	84	61	720
Plant condensate	2,616	3,686	2,130	2,579	1,703	1,464	1,820	1,612	1,354	953	2,015	2,476	24,408
Unfinished oils	1,586	1,654	878	1,490	1,284	452	728	475	901	422	782	1,083	11,735
Total petroleum products	64,199	70,278	60,321	54,173	51,266	55,729	65,061	56,618	61,145	56,059	63,439	76,499	734,787
Total crude and products	206,626	192,308	207,200	197,860	196,014	224,370	244,601	228,839	237,382	232,738	241,806	260,185	2,669,929

[p]Preliminary.
[1]Imports for onshore use of military jet fuel, distillate and residual fuel oils, and receipts from Puerto Rico, the Virgin Islands, and Guam included in these data are based on figures reported to the U.S. Department of the Interior. All other import figures are compiled from U.S. Department of Commerce data.

Table 61.—Crude oil and petroleum products[1] imported into the United States, by country and receiving PAD district

(Thousand barrels)

Country and PAD district	Crude oil	Motor gasoline	Special naphthas	Kerosine	Distillate fuel oil[2]	Residual fuel oil[2]	Jet fuel: Naphtha-type	Jet fuel: Kerosine-type	Liquefied gases	Plant condensate	Asphalt	Unfinished oils	Lubricants	Wax	Petrochemical feedstocks	Miscellaneous oils	Total
1975																	
North America:																	
Bermuda	--	--	--	--	--	129	--	--	--	--	--	--	--	--	--	--	129
Canada	219,175	3,953	43	40	1,672	23,509	--	2,311	30,295	26,972	243	660	8	69	--	--	308,950
Mexico	25,660	--	--	--	131	271	--	--	--	--	--	--	--	6	--	--	26,068
Total	244,835	3,953	43	40	1,803	23,909	--	2,311	30,295	26,972	243	660	8	75	--	--	335,147
Central America and Caribbean:																	
Bahamas	--	--	--	--	1,081	45,302	--	5,987	--	--	--	2,343	--	--	773	150	55,636
British West Indies	--	110	--	--	--	221	--	--	--	--	--	--	--	--	--	--	331
Honduras	--	--	--	--	--	108	--	--	--	--	--	--	--	--	--	--	108
Netherlands Antilles	--	3,183	--	--	4,363	99,215	112	7,870	27	--	4,465	1,046	1	--	588	237	121,107
Panama	--	621	--	--	404	2,181	--	1,479	--	--	--	209	--	--	100	--	4,994
Puerto Rico	--	16,617	--	90	8,231	2,549	--	--	--	--	--	3,143	1,211	526	--	382	32,749
Virgin Islands	--	25,386	--	938	18,934	94,717	8,371	--	--	--	--	--	--	--	--	--	148,346
Total	--	45,917	--	1,028	33,013	244,293	8,483	15,336	27	--	4,465	6,741	1,212	526	1,461	769	363,271
South America:																	
Bolivia	1,940	--	--	--	--	--	--	43	--	--	--	--	--	--	--	--	1,983
Brazil	--	417	--	--	148	1,171	--	208	--	--	--	--	--	--	--	--	1,944
Chile	--	173	--	--	--	--	--	--	--	--	--	--	--	--	--	--	173
Colombia	--	--	--	--	--	3,220	--	--	--	--	--	--	--	9	--	--	3,229
Ecuador	20,679	--	--	--	--	103	--	--	--	--	--	--	--	--	--	--	20,782
Peru	--	--	--	--	--	1,385	--	--	--	--	--	--	--	--	--	--	1,385
Trinidad	42,097	3,758	--	--	5,897	28,862	742	5,170	--	--	3	303	22	--	451	1,187	88,492
Venezuela	144,221	1,843	--	5	6,435	90,147	--	5,185	4,965	--	234	3,152	1	--	--	213	256,401
Total	208,937	6,191	--	5	12,480	124,888	742	10,606	4,965	--	237	3,455	23	9	451	1,400	374,389

Europe:																	
Austria	--	--	--	--	--	42	--	--	--	--	--	--	--	--	--	--	42
Belgium	--	1,265	--	--	184	862	--	--	4	--	--	--	--	--	--	--	2,315
Denmark	--	--	--	--	--	128	--	--	--	--	--	--	--	--	--	--	128
Finland	--	163	--	--	--	--	--	--	--	--	--	--	--	--	--	--	163
France	--	--	--	--	--	2,045	--	--	142	--	--	--	6	4	--	--	2,197
Greece	--	23	--	--	--	16	--	--	--	--	--	--	--	--	--	--	39
Italy	--	1,817	--	--	1,305	5,863	--	718	--	--	--	--	--	31	149	--	9,883
Netherlands	1,500	668	--	--	694	3,642	--	317	--	--	11	--	--	--	--	--	6,832
Norway	4,552	160	--	--	--	1,328	--	--	--	--	--	--	--	--	--	--	6,040
Romania	--	1,390	--	--	770	4,530	--	--	--	--	--	--	--	--	--	--	6,690
Spain	--	--	--	--	143	--	--	115	--	--	--	--	--	--	--	--	258
Sweden	--	233	--	--	--	--	--	--	--	--	--	--	1	--	--	--	234
Turkey	--	347	--	--	--	--	--	--	--	--	--	--	--	--	--	--	347
United Kingdom	125	--	--	--	695	4,255	--	69	4	--	--	--	--	1	--	--	5,149
U.S.S.R	--	--	--	--	556	4,727	--	--	--	--	--	--	--	--	--	--	5,283
West Germany	--	--	--	--	238	405	--	4	--	--	--	--	85	9	--	--	741
Yugoslavia	--	--	--	--	--	--	--	--	--	--	--	15	--	--	--	--	15
Total	6,177	6,066	--	--	4,585	27,843	--	1,223	150	--	11	15	92	45	149	--	46,356
Middle East:																	
Bahrain	--	2,130	--	--	1,019	139	50	2,436	--	--	--	--	--	--	--	--	5,774
Iran	101,575	150	--	--	--	225	--	266	88	--	--	32	--	--	--	--	102,336
Iraq	707	194	--	--	--	--	--	--	--	--	--	--	--	--	--	--	901
Kuwait	1,444	--	--	--	3,275	264	--	57	946	--	--	--	--	--	--	--	5,986
Oman	492	85	--	--	--	--	--	--	31	--	--	--	--	--	--	--	608
Qatar	6,657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,657
Saudi Arabia	256,036	90	--	--	15	--	--	175	3,028	--	--	1,490	--	--	--	--	260,834
United Arab Emirates	42,585	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	42,585
Yemen	--	--	--	--	--	--	--	181	--	--	--	--	--	--	--	--	181
Total	409,496	2,649	--	--	4,309	628	50	3,115	4,093	--	--	1,522	--	--	--	--	425,862
Asia:																	
Brunei	--	280	--	--	--	--	--	25	23	--	--	--	--	--	--	--	328
Gaza Strip	--	--	--	--	--	--	--	--	26	--	--	--	--	--	--	--	26
India	--	--	--	--	--	--	--	--	--	--	--	179	--	--	--	--	179
Indonesia	138,270	206	--	--	--	3,517	--	137	62	--	--	--	--	--	--	--	142,192
Japan	--	--	--	--	--	273	--	5	--	--	--	7	--	15	--	--	300
Korea	--	--	--	--	--	--	--	79	--	--	--	--	--	--	--	--	79
Malaysia	1,951	--	--	--	111	--	--	718	--	--	--	246	--	--	--	--	3,026
Singapore	--	141	--	--	--	483	--	4,324	40	--	--	--	--	--	--	--	4,988
Taiwan	--	--	--	--	--	--	195	--	--	--	--	--	--	--	--	--	195
Total	140,221	627	--	--	111	4,273	195	5,288	151	--	--	432	--	15	--	--	151,313

See footnotes at end of table.

Table 61.-Crude oil and petroleum products[1] imported into the United States, by country and receiving PAD district —Continued

(Thousand barrels)

Country and PAD district	Crude oil	Motor gasoline	Special naphthas	Kerosine	Distillate fuel oil[2]	Residual fuel oil[2]	Jet fuel: Naphtha-type	Jet fuel: Kerosine-type	Liquefied gases	Plant condensate	Asphalt	Unfinished oils	Lubricants	Wax	Petrochemical feedstocks	Miscellaneous oils	Total
1975 —Continued																	
Africa:																	
Algeria	96,459	146	--	--	--	5,238	--	8	891	--	--	160	--	--	--	171	103,073
Angola	26,051	1	--	--	--	1,234	--	--	5	--	--	--	--	--	--	--	27,291
Congo	--	--	--	--	--	1,166	--	--	--	--	--	--	--	--	--	--	1,166
Egypt	1,687	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,687
Gabon	9,811	--	--	--	--	212	--	--	--	--	--	--	--	--	--	--	10,023
Ghana	--	--	--	--	--	1,205	--	--	--	--	--	--	--	--	--	--	1,205
Libya	81,403	202	--	--	--	3,019	--	--	--	--	--	--	--	--	--	--	84,624
Nigeria	272,265	--	--	--	48	5,683	--	--	71	--	--	--	--	--	--	--	278,067
South Africa, Republic of	--	--	--	--	--	--	--	--	--	--	--	--	--	14	--	--	14
Tunisia	839	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	839
Total	488,515	349	--	--	48	17,757	--	8	967	--	--	160	--	14	--	171	507,989
Oceania:																	
Australia	--	--	--	--	--	1,682	--	146	--	--	--	--	--	--	--	--	1,828
Guam	--	--	--	--	--	--	161	--	--	--	--	--	--	--	--	--	161
Hawaii Foreign Trade Zone	--	1,497	--	--	329	1,255	708	151	79	--	--	--	--	--	--	--	4,019
Total	--	1,497	--	--	329	2,937	869	297	79	--	--	--	--	--	--	--	6,008
Total 1975 imports	1,498,181	67,249	43	1,073	56,678	446,528	10,339	38,184	40,727	26,972	4,956	12,985	1,335	684	2,061	2,340	2,210,335
Imports by PAD district:																	
District I	451,549	59,917	--	1,073	54,300	416,105	8,721	19,377	6,716	2,959	4,920	6,038	1,265	668	378	2,340	1,036,326
District II	282,658	1,285	43	--	223	14,015	--	769	17,894	15,101	4	392	9	2	--	--	332,395
District III	437,049	1,554	--	--	1,441	3,957	112	1,752	5,386	--	31	4,170	59	14	1,683	--	457,208
District IV	16,090	22	--	--	1	--	--	4	5,706	6,594	--	--	--	--	--	--	28,417
District V	310,835	4,471	--	--	713	12,451	1,506	16,282	5,025	2,318	1	2,385	2	--	--	--	355,989

1976p																	
North America:																	
Canada	135,690	1,719	45	--	104	21,051	124	781	35,189	24,190	196	140	1	104	--	--	219,334
Mexico	31,670	20	--	--	1	2	--	--	16	--	--	181	--	8	--	--	31,898
Total	167,360	1,739	45	--	105	21,053	124	781	35,205	24,190	196	321	1	112	--	--	251,232
Central America and Caribbean:																	
Bahamas	--	--	--	--	827	36,576	--	1,590	--	--	--	3,484	--	--	177	--	42,654
British West Indies	--	--	--	--	--	28	--	--	--	--	--	--	--	--	--	--	28
Netherlands Antilles	--	217	--	--	2,827	85,756	--	6,423	--	--	3,574	1,676	--	--	--	33	100,506
Panama	--	345	--	--	13	101	--	932	--	--	--	--	--	--	--	--	1,391
Puerto Rico	--	12,666	--	99	7,583	5,184	--	--	--	--	--	4,630	1,164	490	--	440	32,256
Virgin Islands	--	26,318	--	3,064	30,451	91,130	3,595	--	--	--	--	--	--	--	--	--	154,558
Total	--	39,546	--	3,163	41,701	218,775	3,595	8,945	--	--	3,574	9,790	1,164	490	177	473	331,393
South America:																	
Argentina	--	157	--	--	--	--	--	--	--	--	--	--	--	--	--	--	157
Bolivia	1,849	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,849
Colombia	2,041	--	--	--	6	5,696	--	--	--	--	--	25	--	19	--	--	7,787
Ecuador	18,671	--	--	--	--	123	--	--	--	--	--	--	--	--	--	--	18,794
Peru	--	--	--	--	--	1,038	--	--	--	--	--	--	--	--	--	--	1,038
Trinidad	38,142	3,404	--	--	2,845	48,771	--	5,083	--	--	2	83	157	--	1,024	247	99,758
Venezuela	88,139	245	--	--	4,304	155,606	--	811	5,924	218	74	608	--	--	--	--	255,929
Total	148,842	3,806	--	--	7,155	211,234	--	5,894	5,924	218	76	716	157	19	1,024	247	385,312
Europe:																	
Belgium	--	--	--	--	--	1,096	--	--	--	--	--	--	--	--	--	--	1,096
France	--	--	--	--	57	1,629	--	--	104	--	--	--	1	2	--	--	1,793
Greece	--	--	--	--	--	1,774	--	--	--	--	--	--	--	--	--	--	1,774
Italy	--	1,107	--	--	--	12,439	--	35	--	--	--	--	--	--	169	--	13,750
Netherlands	--	--	--	--	--	2,630	--	226	--	--	59	--	--	8	--	--	2,923
Norway	12,881	--	--	--	--	299	--	--	--	--	--	--	--	--	--	--	13,180
Poland	--	--	--	--	--	146	--	--	--	--	--	--	--	--	--	--	146
Romania	--	151	--	--	--	6,683	--	--	--	--	--	--	--	--	--	--	6,834
Spain	--	--	--	--	--	432	--	--	--	--	--	--	--	--	--	--	432
Sweden	--	--	--	--	--	195	--	--	--	--	--	--	--	--	--	--	195
United Kingdom	4,923	380	--	--	--	5,845	--	5	127	--	--	--	31	--	--	--	11,311
U.S.S.R	648	--	--	--	--	3,205	--	--	--	--	--	--	--	--	--	--	3,853
West Germany	--	--	--	--	--	177	--	--	--	--	--	--	4	15	--	--	196
Total	18,452	1,638	--	--	57	36,550	--	266	231	--	59	--	36	25	169	--	57,483

See footnotes at end of table.

Table 61.-Crude oil and petroleum products[1] imported into the United States, by country and receiving PAD district —Continued

(Thousand barrels)

Country and PAD district	Crude oil	Motor gasoline	Special naphthas	Kerosine	Distillate fuel oil[2]	Residual fuel oil[2]	Jet fuel: Naphtha-type	Jet fuel: Kerosine-type	Liquefied gases	Plant condensate	Asphalt	Unfinished oils	Lubricants	Wax	Petrochemical feedstocks	Miscellaneous oils	Total
1976[P] —Continued																	
Middle East:																	
Bahrain	--	1,031	--	--	--	--	--	207	--	--	--	--	--	--	--	--	1,238
Iran	109,073	--	--	--	--	53	--	23	34	--	--	50	--	--	--	--	109,233
Iraq	9,542	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9,542
Israel	2,368	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,368
Kuwait	451	--	--	--	922	--	--	--	372	--	--	--	--	--	--	--	1,745
Oman	10,943	--	--	--	--	--	--	--	4	--	--	--	--	--	--	--	10,947
Qatar	8,631	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8,631
Saudi Arabia	447,071	--	--	--	--	--	--	44	2,317	--	--	665	--	--	--	--	450,097
United Arab Emirates	93,421	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	93,421
Yemen	--	--	--	--	--	--	--	13	--	--	--	--	--	--	--	--	13
Total	681,500	1,031	--	--	922	53	--	287	2,727	--	--	715	--	--	--	--	687,235
Asia:																	
Brunei	--	--	--	--	--	--	--	--	12	--	--	--	--	--	--	--	12
Indonesia	196,283	14	--	--	272	--	--	109	8	--	--	--	--	--	--	--	196,686
Japan	--	--	--	--	2	--	--	1	--	--	--	--	2	3	--	--	8
Malaysia	5,914	--	--	--	--	713	--	--	--	--	--	--	--	--	--	--	6,627
Singapore	--	--	--	--	--	188	--	4,602	--	--	--	--	--	--	--	--	4,790
Total	202,197	14	--	--	274	901	--	4,712	20	--	--	--	2	3	--	--	208,123
Africa:																	
Algeria	149,190	--	--	--	--	5,227	--	--	2,336	--	--	--	--	--	--	--	156,753
Angola	2,426	--	--	--	--	2,223	--	--	--	--	--	--	--	--	--	--	4,649
Canary Islands	--	--	--	--	--	466	--	--	--	--	--	--	--	--	--	--	466
Congo	3,142	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3,142
Egypt	6,311	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,311
Gabon	9,685	--	--	--	--	666	--	--	--	--	--	--	--	--	--	--	10,351
Ghana	--	--	--	--	--	1,438	--	--	--	--	--	--	--	--	--	--	1,438
Ivory Coast	--	--	--	--	--	435	--	--	--	--	--	--	--	--	--	--	435
Libya	162,457	--	--	--	--	3,447	--	--	--	--	--	--	--	--	--	--	165,904
Nigeria	371,092	--	--	--	--	4,117	--	--	--	--	--	--	--	--	--	--	375,209
South Africa, Republic of	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--	--	3

Tunisia	5,400	--	--	--	--	96	--	--	--	--	--	--	--	--	--	--	5,496
Zaire	7,088	--	--	--	--	388	--	--	--	--	--	--	--	--	--	--	7,476
Total	716,791	--	--	--	--	18,503	--	--	2,336	--	--	--	--	3	--	--	737,633
Oceania:																	
Australia	--	--	--	--	--	--	--	--	618	--	--	--	1	--	--	--	619
Hawaii Foreign TradeZone	--	--	--	--	2,256	4,696	1,795	1,584	375	--	--	193	--	--	--	--	10,899
Total	--	--	--	--	2,256	4,696	1,795	1,584	993	--	--	193	1	--	--	--	11,518
Total 1976 imports	1,935,142	47,774	45	3,163	52,470	511,765	5,514	22,469	47,436	24,408	3,905	11,735	1,361	652	1,370	720	2,669,929
Imports by PAD district:																	
District I	517,840	43,506	--	3,163	49,044	492,096	3,719	11,072	6,066	2,237	3,747	7,721	1,244	624	--	720	1,142,799
District II	366,107	465	45	--	97	11,722	--	62	21,938	14,066	1	16	2	4	--	--	414,525
District III	651,511	2,212	--	--	680	1,728	--	325	6,773	218	157	3,750	113	24	1,370	--	668,861
District IV	19,878	--	--	--	--	--	--	--	5,888	5,624	--	--	--	--	--	--	31,390
District V	379,806	1,591	--	--	2,649	6,219	1,795	11,010	6,771	2,263	--	248	2	--	--	--	412,354

[p]Preliminary.
[1]Imports of crude oil, unfinished oils, and plant condensate are reported to the Bureau of Mines. All other import data are compiled from U.S. Department of Commerce and Federal Energy Administration data.
[2]Includes quantities imported duty-free for supply of vessels and aircraft engaged in foreign trade.

Table 62.—Crude petroleum: World production by country

(Thousand 42-gallon barrels)

Country	1974	1975	1976[p]
North America:			
Barbados	48	123	110
Canada	616,532	520,666	488,680
Cuba[e]	775	775	775
Mexico[1]	238,271	294,254	327,285
Trinidad and Tobago	68,131	78,613	77,673
United States[1]	3,202,585	3,052,048	2,971,686
South America:			
Argentina	151,110	144,364	145,561
Bolivia	16,603	14,732	14,856
Brazil	64,751	62,766	61,026
Chile	10,055	8,946	8,372
Colombia	60,867	57,259	53,376
Ecuador	63,678	58,753	68,463
Peru	28,069	26,384	27,936
Venezuela	1,086,332	856,364	839,737
Europe:			
Albania	15,045	15,012	[e]15,012
Austria	15,609	14,205	13,466
Bulgaria	1,095	913	[e]730
Czechoslovakia	1,085	1,017	[e]949
Denmark	689	1,327	1,492
France	7,863	7,460	7,710
Germany, East[e]	2,500	2,500	2,500
Germany, West	44,718	41,470	39,902
Hungary	15,237	15,306	16,343
Italy	6,956	6,743	7,553
Netherlands	10,227	9,676	10,538
Norway	12,707	68,900	101,900
Poland	4,080	4,103	3,376
Romania	107,964	108,739	109,559
Spain	14,334	14,822	11,552
U.S.S.R.[1]	3,373,650	3,608,850	3,822,000
United Kingdom	3,289	8,000	[1]89,006
Yugoslavia	25,613	27,347	28,739
Africa:			
Algeria	368,139	350,753	383,816
Angola	61,392	57,943	36,764
Congo	22,434	13,460	14,274
Egypt	[2]53,715	[2]84,348	120,180
Gabon	73,548	81,948	82,042
Libya	555,291	551,150	704,011
Morocco	191	171	35
Nigeria	823,347	651,890	756,064
Tunisia	31,841	34,567	28,600
Zaire	--	25	9,075
Asia:			
Bahrain	24,597	20,805	21,288
Brunei	70,338	65,932	74,424
Burma	7,581	6,700	8,183
China, People's Republic of[e]	474,500	571,590	645,897
India	55,733	61,611	64,632
Indonesia	501,838	477,055	550,319
Iran	2,197,901	1,952,650	2,168,237
Iraq	720,729	825,521	884,036
Israel[e]	[2]36,500	[2]27,345	268
Japan	4,936	4,378	4,241
Kuwait[3]	929,678	761,634	785,834
Malaysia:			
Sabah	--	--	18,143
Sarawak	29,537	35,774	42,404
Oman	106,046	124,600	133,795
Pakistan	2,923	2,190	2,562
Qatar	189,348	159,482	181,644
Saudi Arabia[3]	3,095,640	2,582,549	3,139,722
Syrian Arab Republic	45,352	65,930	69,685
Taiwan	1,321	1,351	1,555
Thailand[2]	42	[e]42	57
Turkey	24,555	22,167	18,585
United Arab Emirates:			
Abu Dhabi	516,110	511,730	584,225
Dubai	100,375	92,710	114,849
Sharjah	--	13,870	13,540
Oceania:			
Australia	140,396	149,873	152,522
New Zealand[1]	1,385	1,423	3,776
Total	20,537,727	19,497,604	21,187,147

[e]Estimate. [p]Preliminary.
[1]Includes lease condensate.
[2]Estimates of Israeli production from Sinai peninsula oil fields included with Israel rather than with Egypt.
[3]Data for Kuwait and Saudi Arabia include those countries' share from the Kuwait-Saudi Arabia Partitioned Zone.

Phosphate Rock

By W. F. Stowasser[1]

The average unit value of marketable phosphate rock decreased from $22.99 per ton, f.o.b. plant in 1975 to $19.28 per ton, f.o.b. plant in 1976. Although the apparent consumption in 1976 was similar to that of 1975, international trade remained depressed and international prices declined, continuing the trend established in 1975. International prices were not published in 1976. Prices were established by negotiation in a highly competitive market and declined throughout the year.

It became apparent that in the United States and in the world phosphate rock was in more than adequate supply. Stocks in all producing countries increased, particularly in the uncontrolled and competitive industry in the United States. Although exports of phosphate rock declined from 1975 levels, integrated phosphate fertilizer producers in the United States continued, as they did in 1975, to export phosphate intermediates and concentrated phosphate fertilizer.

The price of phosphoric acid, triple superphosphate, and diammonium phosphate in the export market reached levels of $450 per ton, $350 per ton, and $400 per ton, respectively, f.o.b. U.S. gulf ports in 1974. Prices declined sharply in 1975 and, by mid-1976, the export price of phosphoric acid was down to the order of $175 per ton, triple superphosphate declined to $80 per ton, and diammonium phosphate sold for about $100 per ton, f.o.b. gulf ports. Integrated fertilizer producing firms in the United States exported at these price levels into Western Europe and Asian markets. Fertilizer producers in Western Europe and Japan were frequently unable to compete with imported products from countries with a raw material base because both phosphate rock import costs as well as energy costs were much greater than pre-1974 costs.

Estimated world production of phosphate rock in 1976 was 117.9 million short tons, about the same as the 118.3 million short tons produced in 1975.

Although Morocco acquired the phosphate mines in the Spanish Sahara in 1975, production from the Bu Craa mine was not a factor in world supply in 1976. The conveyor belt was damaged and truck transportation from the mine to the port of El Aaiún limited operations. It is estimated that Morocco exported from 15.5 to 16.0 million short tons of phosphate rock in 1976, an improvement over the 14.5 million short tons exported in 1975.

Legislation and Government Programs.—Environmental regulations enacted since 1969 have had a signficant impact on the phosphate industry. The National Environmental Policy Act (NEPA) of 1969 requires that a Federal agency prepare an Environmental Impact Statement (EIS) prior to taking any action that affects the environment such as granting preference right mining permits or leasing land for mining and processing purposes. It is common practice for the company requesting a permit to furnish all the information as a draft EIS. This is a major expense for a phosphate company and will require 2 to 4 years to produce, to pass through a review process, and to obtain approval. During this time, the changing costs and selling prices in the marketplace can reduce the economic incentives for the company to proceed with a mine and plant. This appears to be the situation that has developed during the past several years. Changing economics and shifts in the supply and demand for phosphate rock have made it likely that firms that initiated applications for permits to mine phosphate rock on

[1]Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient phosphate rock statistics

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Mine production	126,651	139,713	155,847	187,516	170,097
Marketable production	40,831	42,137	45,686	48,816	49,241
Value	$207,910	$238,667	$501,429	$1,122,184	$949,365
Average per ton	$5.09	$5.66	$10.98	$22.99	$19.28
Sold or used by producers	43,755	45,043	48,435	46,439	44,677
Value	$223,005	$254,846	$529,141	$1,052,995	$857,189
Average per ton	$5.10	$5.66	$10.92	$22.67	$19.19
Exports	14,275	13,875	r13,897	r12,272	10,400
P_2O_5 content	4,673	4,502	4,468	3,955	3,332
Value	$75,376	$82,983	r$194,015	r$429,222	$272,823
Average per ton	$5.28	$5.98	r$13.96	r$34.98	$26.23
Imports for consumption[1]	55	65	182	37	51
Value	$1,416	$1,288	$8,999	$1,604	$2,234
Average per ton	$25.75	$19.82	$49.45	r$43.83	$43.59
Consumption, apparent [2]	29,535	31,233	34,720	r34,203	34,328
World: Production	99,287	108,823	r121,240	r118,254	117,898

rRevised.
[1]Bureau of the Census data.
[2]Measured by sold or used, plus imports, minus exports.

public or private land 2 or 3 years ago would not proceed if the permits were granted.

Applications to mine phosphate rock in the Los Padres National Forest of California, the Caribou National Forest in Idaho, and the Osceola National Forest in northern Florida, that have been pending for many years were not granted in 1976. A task force under the direction of the U.S. Geological Survey completed an EIS on developing phosphate resources in southeastern Idaho. A final EIS on mining phosphate rock in the Los Padres National Forest was completed in 1976. A 2-year study to determine the effects of potential phosphate mines in the Osceola National Forest on the aquifer's ability to supply water and the water demands of the two logical mining units was started in 1976. In North Carolina, the Corps of Engineers has delayed North Carolina Phosphate Corp.'s plans to develop a new mine and plant in order to study the issuance of dredge and fill permits for South Creek, a tributary of the Pamlico River.

In central Florida, phosphate rock was mined prior to 1976 only in Polk County. Two mines were permitted to be constructed in Hillsborough County and one of these was near completion at the end of 1976. Development of Regional Impact (DRI) statements, similar documents to EIS, were submitted for mines in Manatee and Hardee Counties, permits were not granted in 1976. The delay in permitting new mines in central Florida was further extended when, in May, President Ford ordered the Council on Environmental Quality to prepare an EIS on central Florida that established a moratorium on new mine development in this area.

Because of rapid population growth in Florida, high water demand from communities and industries, falling ground water levels, and deterioration of water quality, the State has developed one of the most comprehensive sets of laws and regulations to control development of resources. Regulatory power is distributed between local and State governments and special districts. The practical effect of this State legislation is that the phosphate industry must deal with a complex set of governmental regulations, including the Florida State Comprehensive Planning Act of 1972 and the Florida Environmental Land and Water Management Act of 1972. Policies affecting surface mining are established by these Acts. To strengthen the powers of local governments, the Local Government Comprehensive Planning Act of 1975 requires municipalities and counties to prepare and adopt plans to guide development. The Florida Water Resources Act of 1972 established State and regional programs to manage water resources and related land resources, including issuing permits for water used in mining. Florida has 67 counties and several hundred municipalities. By statutory authority, the local level of government can be a decisive factor in influencing the use of land and resources. Some counties have little or no land planning programs, some have adopted many types of land use control devices, and most have some type of planning and regulation. Analysis of local government involvement is discussed in a Geological Survey open file report.[2]

DOMESTIC PRODUCTION

Marketable phosphate rock production was 49,241,000 tons, an increase of 425,000 tons or 1% over that of 1975. The value of the marketable rock was $949,365,000, a decrease of 15.4% from that of 1975. The average grade of ore mined in the United States was 11.8% P_2O_5, and the average grade of marketable rock was 30.7% P_2O_5, about the same as that of 1975. The average weight recovery of concentrate and rock marketable as mined was 28.9%, an improvement over the 26.0% weight recovery in 1975. The average P_2O_5 recovery was 75.4% in 1976, considerably more than the 64% in 1975. In the United States, Florida and North Carolina produced 41,554,000 tons (84.4%) of the total marketable phosphate rock, the Western States produced 5,886,000 tons (11.9%), and Tennessee produced 1,801,000 tons (3.7%).

Florida and North Carolina.—Production of marketable phosphate rock was 41,554,000 tons, an increase of 2.1% over that of 1975. The value of marketable rock was $867,092,000, a decrease of $133,260,000 or 13.3% less than that of 1975.

The average grade of phosphate ore mined was 11% P_2O_5, somewhat less than the average grade of 11.8% P_2O_5 ore mined in 1975. The average grade of marketable rock was 31.3% P_2O_5, the same as the average grade produced in 1975.

The average weight recovery of concentrates and rock marketable as mined was 26.4%, an improvement over the average weight recovery of 23.4% in 1975. The average P_2O_5 recovery was 75%, a significant increase over the P_2O_5 recovery of 62.2% achieved in 1975. The improvement in weight and P_2O_5 recovery was attributed to normal operations in 1976 of mines that were started in 1975 and that stockpiled concentrate feed for processing in 1976.

Agrico Chemical Co.; Borden, Inc.; Brewster Phosphates; Florida Agglite Corp.; Gardinier, Inc.; W. R. Grace & Co.; International Minerals & Chemical Corp.; T. A. Minerals Corp.; Mobil Oil Corp.; Occidental Petroleum Corp.; Swift Agricultural Chemicals Corp.; and U.S.S. Agri-Chemicals, Inc., produced marketable phosphate rock from the Bone Valley Formation in central Florida and a similar matrix in northern Florida. Howard Phosphate Co.; Kellogg Co.; Loncala Phosphate Co.; and Manko Co., Inc. mined 29,000 tons of soft rock, a waste from nonoperating hard rock mines, in central Florida.

In North Carolina, Texasgulf, Inc. increased mining capacity with the addition of a 30-inch electric hydraulic dredge to strip the top 40 feet of overburden from the phosphate deposit and a 45-cubic-yard dragline. The mine, washer, and flotation plant capacity was increased to 5 million tons per year of product if operated in a single float mode. North Carolina Phosphate Corp., jointly owned by Agrico Chemical Co. and Kennecott Copper Corp., continued permitting procedures. All permits were issued except for a dredge and fill permit from the Corps of Engineers to deepen South Creek to prepare for barge traffic from the plant to Morehead City, the deepwater port on Pamlico Sound.

In northern Florida, Occidental Chemical Co., a division of Occidental Petroleum Corp,. opened the Swift Creek mine in early 1976, and after a temporary shutdown in

[2]Imhoff, E. A. An Analysis of Selected Laws and Governmental Programs in Florida, as Related to Mineral Resource Management and Surface Mining. U. S. Geological Survey Open File Rept. 76-648, 1976.

midyear, finally closed the mine at yearend as demand declined for phosphate rock. Occidental continued to operate the nearby Suwanee River mine.

In central Florida, Agrico Chemical Co. completed the first full year of operating the Fort Green mine and closed the Palmetto mine because reserves were exhausted. Construction continued on Brewster Phosphates' Fort Lonesome mine and Borden, Inc.'s Big Four mine in Hillsborough County. The Fort Lonesome mine is scheduled to start producing in early 1977, and the Big Four mine is planned to replace the Tenoroc mine in Polk County that is scheduled to be phased out in late 1977 or early 1978 as this reserve is depleted. C.F. Industries, Inc. purchased 19,555 acres of land in Hardee County for $101,547,592. The firm plans to initially produce 2 million tons per year of phosphate rock for its chemical plants at Bartow and Plant City, Fla. Farmland Industries purchased about 7,000 acres in Hardee County for $33.3 million. Plans are to mine the reserve in the 1980's. Freeport Phosphate Mining Co. announced a lease agreement with Limestone Land Co. to mine 6,200 acres in Hardee County. W.R. Grace completed construction of a new beneficiation plant near Bradley Junction, Fla. The Hooker Prairie deposit will be mined and treated at this new plant. In addition to the noted land acquisitions, Gardinier, Inc.; Mississippi Chemical Co.; Mobil Chemical Co.; United States Steel Corp. and International Minerals & Chemical Corp., all purchased substantial acres of phosphate land in Hardee County.

Western States.—Production of marketable phosphate rock was 5,886,000 tons, similar to the 5,825,000 tons produced in 1975.

The value of marketable rock decreased to $67,746,000, 27.2% less than the value in 1975. The average grade of mined phosphate ore was 22.3% P_2O_5. The average grade of mined phosphate rock used without beneficiation was 26.2% P_2O_5. The average grade of beneficiated rock was 31.8% P_2O_5. The average grade of all marketable rock was 28.1% P_2O_5. Of the total phosphate rock produced in the Western States, 65.9% was used directly and the balance, 34.1%, was beneficiated product. The weight recovery of the combined beneficiated concentrates and rock used as mined was 64.6% and P_2O_5 recovery was 81.1%.

Beker Industries Corp., Monsanto Co., J.R. Simplot Co., and Stauffer Chemical Co. mined and processed phosphate rock in Idaho. In Montana, Cominco American, Inc., recovered phosphate rock from underground mines near Garrision. Stauffer Chemical Co. mined phosphate rock in Wyoming and in two areas in Utah. Jon-T Phosphates, Inc. mined some phosphate rock in Van Buren County, Ark. Meramec Mining Co., Sullivan, Mo., recovered apatite concentrate from Pea Ridge iron ore mine tailings.

During the year, Beker Industries Corp.'s Maybie Canyon mine and fertilizer complex at Conda, Idaho, was closed when demand for fertilizer in the Western States declined in June of 1976. Jon-T Phosphates, Inc. also suspended production indefinitely when demand for phosphate rock slumped. A draft EIS, "Development of Phosphate Resources in Southeastern Idaho," prepared jointly by the U.S. Department of the Interior and the U.S. Department of Agriculture, presented an analysis of the broad cumulative impacts of existing and proposed phosphate resource development in southeastern Idaho, as well as an analysis of specific applications pending before the Federal Government. The final EIS had not been issued by the close of the year. No new mines were developed in the Western States in 1976.

Tennessee.—Production of marketable phosphate rock was 1,801,000 tons, a decrease of 490,000 tons or 21.4% less than reported in 1975. The value of the marketable rock decreased from $28,803,000 in 1975 to $14,527,000 in 1976, a decrease of 49.6%.

The average grade of mined ore was 20.4% P_2O_5, the average weight recovery of concentrates was 54.1%, and the recovery of P_2O_5 was 68.1%. A small quantity of phosphate rock was used in electric furnaces without beneficiation. The average grade of phosphate rock that was beneficiated and used directly was 25.8% P_2O_5.

Hooker Chemical Co.; M.C. West, Inc.; Monsanto Industrial Chemicals Co.; and Stauffer Chemical Co., mined and processed phosphate rock in Tennessee for reduction in electric furnaces to elemental phosphorus. The Tennessee Valley Authority closed its phosphate mines in Tennessee and its electric furnaces at Muscle Shoals, Ala.

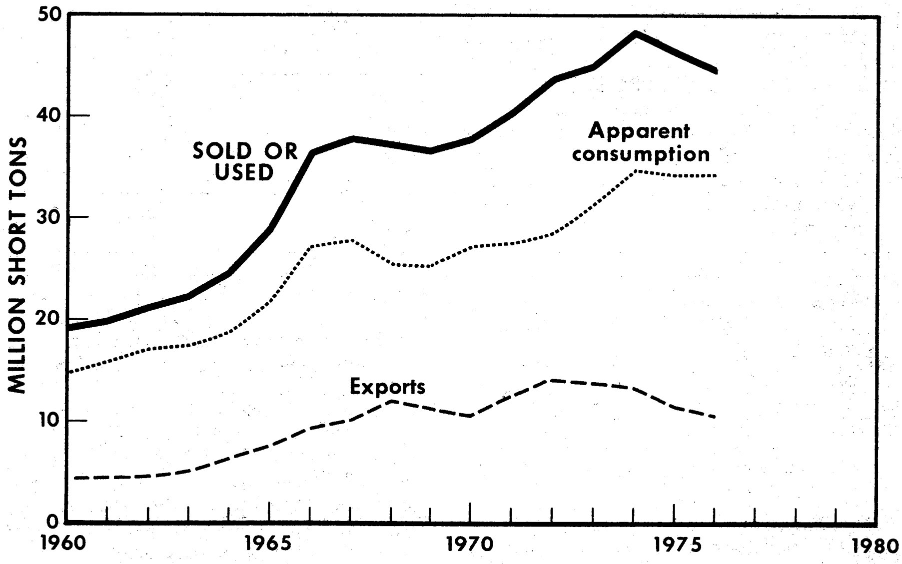

Figure 1.—Phosphate rock (sold or used), apparent consumption, and exports.

Table 2.—Production of phosphate rock in the United States, by State

(Thousand short tons and thousand dollars)

	Mine production		Mine production used directly		Washer production		Marketable production		
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Value
1975:									
Florida and North Carolina	173,761	20,493	28	6	40,671	12,748	40,699	12,754	1,000,352
Tennessee	4,052	808	283	67	2,008	520	2,291	588	28,803
Western States[1]	9,702	2,182	3,138	834	2,687	852	5,825	1,686	93,029
Total[2]	187,516	23,483	3,449	907	45,366	14,121	48,816	15,028	1,122,184
1976:									
Florida and North Carolina	157,646	17,341	29	6	41,525	12,995	41,554	13,001	867,092
Tennessee	3,332	681	50	12	1,751	452	1,801	464	14,527
Western States[1]	9,118	2,037	3,877	1,014	2,009	638	5,886	1,652	67,746
Total[2]	170,097	20,060	3,956	1,032	45,285	14,085	49,241	15,118	949,365

[1]Includes Arkansas, California, Idaho, Missouri, Montana, Utah, and Wyoming.
[2]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Apparent consumption of marketable phosphate rock, defined as the quantity sold or used plus imports minus exports, increased only 125,000 tons to 34,328,000 tons in 1976. According to producers' reports, the quantity of phosphate rock sold or used in 1976 was 44,677,000 tons, a considerable reduction from the 46,439,000 tons sold or used in 1975. Of the total sold or used in 1976, 76.7% was consumed domestically and 23.3% was exported.

The consumption pattern as reported by producers is shown in table 3. Of the total sold or used, including both domestic and export markets, the distribution pattern in 1976 for the domestic segment was wet-process phosphoric acid 58.3%, normal superphosphate 2.6%, triple superphosphate

3.4%, defluorinated rock 0.7%, direct applications 0.1%, elemental phosphorus 11.1%, and ferrophosphorus 0.5%, for a total of 76.7% or 34,277,000 tons.

The percent distribution by grade of marketable phosphate rock consumed in the United States and sold in the export market in 1976 is compared with the distribution patterns in 1974 and 1975 in the following tabulation:

Grade, percent BPL[1] content	Distribution (percent)		
	1974	1975	1976
Less than 60	5.6	9.4	7.8
60 to 66	20.8	14.7	14.6
66 to 70	42.0	48.4	53.8
70 to 72	12.2	10.8	9.4
72 to 74	11.6	10.7	8.3
Over 74	7.8	6.0	6.1

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Florida and North Carolina.—The quantity of phosphate rock sold or used decreased from 37,921,272 tons in 1975 to 37,392,197 tons in 1976. Of the total sold or used in 1976, 74.1% was consumed domestically and 25.9% was exported. Of that consumed domestically, 24,311,000 tons (87.8%) was used to produce wet-process phosphoric acid, 1,141,000 tons (4.1%) for normal superphosphate, 1,450,000 tons (5.2%) for triple superphosphate, 319,000 tons (1.2%) for defluorinated rock, 38,000 tons (0.1%) for direct applications, and 451,000 tons (1.6%) for elemental phosphorus and ferrophosphorus.

The percent distribution by grade of the marketable rock sold or used from Florida and North Carolina in 1974, 1975, and 1976 is shown in the following tabulation. Exports are included in this distribution pattern:

Grade, percent BPL[1] content	Distribution (percent)		
	1974	1975	1976
Less than 60	0.2	0.1	0.2
60 to 66	17.0	14.8	13.4
66 to 70	47.2	55.0	60.2
70 to 72	14.3	11.2	11.2
72 to 74	11.9	11.5	7.7
Over 74	9.4	7.4	7.3

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Western States.—The quantity of marketable phosphate rock sold or used decreased from 6,124,140 tons in 1975 to 5,376,922 tons in 1976. Of the total sold or used in 1976, 86.6% was consumed in the United States and 13.4% was exported.

Of that consumed in the United States, expressed as a percent of the total sold or used from the Western States, 1,718,768 tons (32.0%) was used for wet-process phosphoric acid, 41,000 tons (0.8%) was used for normal superphosphate, 53,000 tons (1.0%) was used for triple superphosphate, 6,000 tons (0.1%) was used for direct applications, 2,754,299 tons (51.2%) was used to produce elemental phosphorus, and 85,185 tons (1.6%) was collected in ferrophosphorus.

The percent distribution by grade of marketable rock sold or used from the Western States in 1974, 1975, and 1976 is shown in the following tabulation:

Grade, percent BPL[1] content	Distribution (percent)		
	1974	1975	1976
Less than 60	35.8	38.8	37.7
60 to 66	22.5	13.2	18.5
66 to 70	23.5	25.9	28.5
70 to 72	3.5	12.2	--
72 to 74	14.3	9.9	15.3
Over 74	0.4	--	--

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Tennessee.—The quantity of marketable phosphate rock sold or used declined from 2,393,000 tons in 1975 to 1,908,000 tons in 1976. All of the rock was used in electric furnaces to produce elemental phosphorus and industrial chemicals. Most of the elemental phosphorus was converted into phosphoric acid, the base for sodium and calcium phosphates and anhydrous derivatives.

The percent distribution by grade of marketable rock sold or used in Tennessee in 1974, 1975, and 1976 is compared in the following tabulation:

Grade, percent BPL[1] content	Distribution (percent) 1974	1975	1976
Less than 60	19.7	80.9	72.1
60-66	75.6	17.5	26.8
66-70	4.7	1.6	1.1
70-72	--	--	--
72-74	--	--	--
Over 74	--	--	--

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Table 3.—Phosphate rock sold or used by producers in the United States, by use

(Thousand short tons)

Use	1975 Rock	1975 P_2O_5 content	1976 Rock	1976 P_2O_5 content
Domestic:				
Wet process phosphoric acid	25,543	7,891	26,030	8,019
Normal superphosphate	1,017	315	1,182	368
Triple superphosphate	1,627	535	1,503	487
Defluorinated rock	172	59	319	106
Direct applications	r135	r39	44	9
Elemental phosphorus	r5,418	r1,411	4,978	1,298
Ferrophosphorus	r255	r66	220	57
Total [1]	34,167	10,315	34,277	10,345
Exports	12,272	3,955	10,400	3,332
Grand total	46,439	14,270	44,677	13,677

rRevised.
[1]Data may not add to totals shown because of independent rounding.

Table 4.—Phosphate rock sold or used by producers in the United States, by grade and State in 1976

(Thousand short tons and thousand dollars)

Grade, percent BPL[1] content	Florida and North Carolina Rock	P_2O_5 content	Value	Tennessee Rock	P_2O_5 content	Value
Below 60	83	20	1,848	1,376	342	9,573
60 to 66	5,006	1,439	110,587	W	W	W
66 to 70	22,523	6,930	428,951	W	W	W
70 to 72	4,188	1,361	86,793	--	--	--
72 to 74	W	W	W	--	--	--
Plus 74	W	W	W	--	--	--
Total[2]	37,392	11,658	775,096	1,908	494	15,326

Grade, percent BPL[1] content	Western States Rock	P_2O_5 content	Value	Total United States Rock	P_2O_5 content	Value
Below 60	2,030	504	16,163	3,489	867	27,585
60 to 66	W	W	W	6,510	1,861	126,604
66 to 70	W	W	W	24,079	7,408	461,216
70 to 72	--	--	--	4,188	1,361	86,793
72 to 74	W	W	W	W	W	W
Plus 74	--	--	--	W	W	W
Total[2]	5,377	1,525	66,767	44,677	13,677	857,189

W Withheld to avoid disclosing individual company confidential data, included in total.
[1]Bone phosphate of lime, $Ca_3(PO_4)2$.
[2]Data may not add to totals shown because of independent rounding.

Table 5.—Phosphate rock sold or used by producers, by use and State

(Thousand short tons)

Use	Florida and North Carolina		Tennessee		Western States		Total[1] United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1975								
Domestic:								
Agricultural	26,397	8,169	--	--	2,097	670	28,494	8,838
Industrial	390	115	2,393	617	2,890	745	5,673	1,477
Total	[r]26,787	8,284	2,393	617	4,987	1,415	34,167	10,315
Exports[2]	11,135	3,610	--	--	1,137	345	12,272	3,955
Total[1]	37,921	11,894	2,393	617	6,124	1,760	46,439	14,270
1976								
Domestic:								
Agricultural	27,259	8,412	--	--	1,820	578	29,079	8,990
Industrial	451	132	1,908	494	2,839	729	5,198	1,355
Total	27,710	8,544	1,908	494	4,659	1,308	34,277	10,345
Exports[2]	9,682	3,114	--	--	718	217	10,400	3,332
Total[1]	37,392	11,658	1,908	494	5,377	1,525	44,677	13,677

[r]Revised.
[1]Data may not add to totals shown because of independent rounding.
[2]Exports reported to Bureau of Mines by companies.

Table 6.—Florida phosphate rock sold or used by producers, by type

(Thousand short tons and thousand dollars)

Year	Land pebble[1]				Soft rock				Total[2]			
	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1972	36,913	11,863	188,205	$5.10	21	4	121	$5.87	36,934	11,868	188,326	$5.10
1973	36,894	11,716	205,328	5.57	22	4	154	7.00	36,916	11,720	205,482	5.57
1974	39,879	12,547	436,587	10.95	41	8	571	13.93	39,920	12,555	437,158	10.95
1975	37,893	11,888	926,813	24.46	28	6	503	17.96	37,921	11,894	927,316	24.45
1976	37,360	11,652	774,517	20.73	32	7	580	18.12	37,392	11,658	775,096	20.73

[1]Includes North Carolina.
[2]Data may not add to totals shown because of independent rounding.

Table 7.—Tennessee phosphate rock sold or used by producers

(Thousand short tons and thousand dollars)

Year	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1972	2,240	587	11,188	$4.99
1973	2,665	699	13,812	5.18
1974	2,607	708	20,594	7.90
1975	2,393	617	29,921	12.50
1976	1,908	494	15,326	8.03

STOCKS

Stocks of marketable phosphate rock in the United States increased from 9,946,045 tons at the beginning of the year to 15,181,760 tons at yearend. At the end of 1976, inventories reported were larger than in prior years. It was the second consecutive year of a significant increase in inventory levels.

In Florida and North Carolina, stocks increased from 8,533,323 tons at the beginning of the year to 13,296,312 tons at yearend. In Tennessee, stocks declined from 307,364 tons to 280,567 tons during the year. Stocks in the Western States increased from 1,105,358 tons to 1,604,881 tons during the year.

PRICES

The prices of phosphate rock sold in either the domestic or export markets were not published. The selling price, negotiated between the producer and consumer, is not public information. Although some producers publish price lists, contractual prices are not required to follow published prices. An indication of domestic price levels for phosphate rock was published in the Chemical Marketing Reporter. Table 8 shows prices for Florida land-pebble phosphate rock at the end of 1976.

A similar price tabulation was not available for phosphate rock produced in other parts of the country. Phosphate rock in Tennessee is normally used in local electric furnaces as is a large part of the production from the Western States. Some phosphate rock from the Western States enters the merchant rock market but not in quantities comparable with those from Florida. Most of the production in North Carolina is captively consumed by Texasgulf, Inc. and converted into higher value products.

The producing companies report the grade and value[3] of marketable phosphate rock semiannually to the Bureau of Mines. The average 1976 unit value of marketable rock reported by producers, and estimated if unspecified, was $19.28 per ton f.o.b plant, 16.1% less than the $22.99 per ton value reported in 1975. The average unit value of land-pebble rock reported sold or used in the domestic and export market from Florida and North Carolina decreased from $24.46 per ton in 1975 to $20.73 per ton in 1976. The average value of all marketable rock sold or used from Florida and North Carolina, including soft rock was also $20.73 per ton. In the Western States, the unit value of marketable rock sold or used decreased from $15.64 per ton in 1975 to $12.42 per ton in 1976. The unit value of marketable rock sold in Tennessee declined from $12.50 per ton in 1975 to $8.03 per ton in 1976.

The average unit value of phosphate rock exported from the United States decreased from $34.98 per ton in 1975 to $26.23 per ton in 1976, a 25% decrease. The unit value of marketable rock exported from Florida and North Carolina decreased from $36.57 per ton in 1975 to $26.34 per ton in 1976. The unit value of phosphate rock exported from the Western States increased from $19.32 per ton in 1975 to $24.84 per ton in 1976. Tennessee rock was not exported.

The Phosphate Rock Export Association published an export price schedule effective January 1, 1976. This schedule is shown in table 9. Although the Phosphate Rock Export Association did not publish new price schedules during the year, price reductions were made in April and December 1976. Estimates of the price schedules are also shown in table 9. Price estimates are averages as each contract is independently negotiated between buyer and seller and adjustments for factors other than grade are normal.

Early in 1976, the Office Cherifien des Phosphates of Morocco published phosphate rock price schedules that were to be effective as of January 1976. These are shown in table 10. International phosphate rock price erosion that began in 1975 continued into 1976 and, as the year progressed, Moroccan export prices declined to the estimated levels shown in table 10 at yearend.

At the end of 1976, international demand for phosphate rock was weak and a further decline in prices appeared certain early in 1977.

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[3]Value, if sold, net selling price f.o.b. plant, or, if used, estimated value from comparable selling prices or developed price; that is, cost plus overhead and profit.

Table 8.—Prices of Florida land - pebble phosphate rock, washed, dried, unground, in bulk, carload lots, f.o.b. mine

(Per short ton)

Grade, percent BPL[1] content	Price range
73 to 75	$34.00-$37.00
70 to 72	30.00- 32.00
66 to 68	24.00- 26.00
62 to 64	19.00- 21.00

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)= 0.458% P_2O_5.

Source: Chemical Marketing Reporter, v. 211, No. 1, Jan. 3, 1977, p. 58.

Table 9.—Phosphate Rock Export Association price schedule, per metric ton, unground, f.o.b. vessel Tampa Range or Jacksonville, Fla.

Grade, percent BPL[1] content	January 1976[2]	April 1976[3]	December 1976[3]
75	$47	$44	$34
72	41	39	32
70	37	36	30
68	33	33	28
66	30	30	26

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)= 0.458% P_2O_5.
[2]Plus 55 cents per metric ton severance tax.
[3]Estimated price plus 55 cents per metric ton severance tax.

Table 10.—Moroccan phosphate rock export prices,[1] per metric ton, f.a.s. Safi or Casablanca

Grade, percent BPL[2] content	January 1976	December 1976
Khouribga:		
77%	$51.50	$41.00
75%	48.50	37.00
70%	46.00	32.00
Youssoufia:		
70%	43.00	30.00

[1]Plus 55 cents per metric ton loading charge.
[2]1.0% BPL (bone phosphate of lime or tricalcium phosphate)= 0.458% P_2O_5.

Source: Office Cherifien des Phosphates.

FOREIGN TRADE

Phosphate rock producers reported 10,400,000 tons were exported in 1976, a decline of 15.3% from the 12,272,000 tons exported in 1975. Of the total exported in 1976, 93.1% was shipped from Florida and North Carolina and 6.9% originated in the Western States. Exports of phosphate rock from Florida declined, phosphate rock exports from North Carolina are either small tonnages or not a factor in this market, and exports from the Western States declined 36.8% compared with exports in 1975.

The average calculated unit value of exported phosphate rock in 1976 was $26.23 per ton, a significant reduction from the comparable value of $34.98 per ton calculated from reported tons and value in 1975.

The United States imported 51,000 tons of phosphate rock in 1976, somewhat more than the 37,000 tons imported in 1975. The unit values in 1976 and 1975 were $43.59 and $43.83 per ton, respectively. Most of the phosphate rock was imported from the Netherlands Antilles.

Table 11.—U.S. exports of phosphate rock, by country

(Thousand short tons and thousand dollars)

Destination	1975		1976	
	Quantity	Value	Quantity	Value
Florida phosphate rock:				
Austria	28	144	107	4,173
Belgium-Luxembourg	709	29,641	827	26,610
Brazil	561	24,270	711	25,655
Canada	2,623	67,367	1,970	41,566
Chile	29	1,878	--	--
Colombia	48	2,200	18	573
Costa Rica	--	--	12	325
Ecuador	16	709	22	704
El Salvador	5	217	12	426
France	572	19,133	589	16,480
Germany:				
East	--	--	18	401
West	589	20,136	558	14,085
India	249	9,655	261	11,218
Iran	415	23,614	305	9,349
Ireland	--	--	25	656
Italy	228	8,540	105	3,157
Japan	1,842	80,721	1,516	53,311
Korea, Republic of	670	30,538	763	30,059
Mexico	1,047	40,141	434	12,378
Netherlands	575	18,822	758	19,852
Norway	83	2,837	61	2,104
Peru	11	495	6	184
Philippines	144	7,232	84	2,950
Poland	466	19,662	210	6,328
Portugal	--	--	4	129
Romania	144	6,216	169	4,926
Spain	52	1,188	18	424
Sweden	69	2,987	113	3,876
Switzerland	--	--	26	871
Taiwan	16	863	50	1,727
United Kingdom	129	5,673	181	5,416
Other	1	45	2	139
Total	11,321	424,924	9,935	300,052
Other phosphate rock:[1]				
Argentina	5	100	--	--
Belgium-Luxembourg	--	--	12	314
Brazil	13	444	71	2,068
Canada	930	21,247	743	18,402
Costa Rica	11	697	--	--
Dominican Republic	(2)	2	--	--
El Salvador	6	383	--	--
France	3	50	35	620
Germany, West	16	278	88	1,568
Iran	68	4,096	(2)	10
Japan	6	195	--	--
Mexico	(2)	4	(2)	3
Netherlands	223	8,483	36	1,647
Peru	(2)	20	--	--
Poland	--	--	32	804
Romania	--	--	64	1,845
Taiwan	3	600	--	--
Venezuela	(2)	2	(2)	5
Other	1	28	3	72
Total	1,285	36,629	1,084	27,358
Grand total	12,606	461,553	11,019	327,410

[1]Includes colloidal and sintered matrix, Tennessee, Idaho, Montana, and soft phosphate rock.
[2]Less than 1/2 unit.

Table 12.—U.S. exports of superphosphates, by country

(Thousand short tons and thousand dollars)

Destination	1975		1976	
	Quantity	Value	Quantity	Value
Algeria	--	--	45	2,959
Argentina	5	1,700	4	352
Australia	1	105	7	634
Bangladesh	80	9,799	35	3,889
Belgium-Luxembourg	16	1,814	36	2,760
Brazil	377	55,707	407	30,365
Canada	69	5,410	56	4,928
Chile	67	19,406	92	7,466
Colombia	13	2,855	5	579
Costa Rica	2	525	9	803
Denmark	--	--	25	1,790
Dominican Republic	2	813	21	2,138
Ecuador	(1)	4	(1)	1
El Salvador	--	--	1	91
France	r73	r7,248	141	12,072
Germany:				
East	6	722	4	413
West	40	4,488	107	9,941
Guyana	6	1,300	1	179
Hong Kong	(1)	10	(1)	14
Hungary	59	6,989	147	13,638
Indonesia	99	26,595	--	--
Iraq	11	3,200	--	--
Ireland	--	--	27	1,906
Italy	29	2,994	35	2,787
Jamaica	3	447	2	154
Japan	13	2,986	44	3,064
Korea, Republic of	44	16,121	(1)	1
Mexico	5	316	1	60
Netherlands	--	--	6	410
New Zealand	(1)	12	(1)	4
Niger	--	--	1	58
Panama	--	--	2	289
Peru	12	3,996	--	--
Philippines	1	211	--	--
Poland	85	8,684	--	--
Singapore	--	--	3	378
South Africa, Republic of	--	--	4	2
Spain	6	141	11	1,202
Sri Lanka	8	2,051	--	--
Taiwan	3	391	2	189
Thailand	--	--	2	127
United Kingdom	12	1,177	4	404
Venezuela	13	3,080	1	215
Yugoslavia	--	--	43	4,069
Other	6	1,601	3	504
Total	r1,166	r192,898	1,334	110,835

r Revised.
1 Less than 1/2 unit.

Table 13.—U.S. exports of ammonium phosphates, by country

(Thousand short tons and thousand dollars)

Destination	1975[1]		1976	
	Quantity	Value	Quantity	Value
Afghanistan	26	7,056	20	2,328
Algeria	--	--	15	1,327
Argentina	9	2,964	36	4,162
Australia	--	--	32	3,961
Belgium-Luxembourg	29	4,537	182	19,155
Bolivia	1	284	(2)	54
Brazil	462	77,724	357	36,564
Canada	92	12,811	125	13,849
Chile	37	12,229	4	476
Colombia	6	1,358	(2)	2
Costa Rica	19	5,156	22	2,648
Dominican Republic	22	3,931	12	1,646
Ecuador	20	6,993	--	--
El Salvador	17	5,808	48	5,056
Ethiopia	57	10,469	8	412
France	161	28,188	267	32,282
Germany, West	--	--	8	902
Guatemala	(2)	30	2	324
India	559	159,326	--	--
Indonesia	88	22,975	--	--
Iran	141	46,936	3	250
Ireland	--	--	13	1,230
Italy	326	51,335	425	49,305
Ivory Coast	--	--	9	990
Japan	62	10,919	155	17,168
Kenya	11	1,455	--	--
Libya	23	4,520	--	--
Malaysia	--	--	7	775
Mauritania	--	--	3	358
Mexico	33	6,540	(2)	2
New Zealand	13	2,168	16	1,892
Nicaragua	1	233	4	408
Pakistan	6	854	293	34,923
Panama	(2)	1	--	--
Peru	36	11,082	--	--
Philippines	11	4,128	--	--
Portugal	16	2,988	8	879
South Africa, Republic of	--	--	7	788
Spain	22	3,332	39	3,733
Taiwan	--	--	17	1,677
Thailand	50	10,115	12	1,890
Turkey	--	--	54	5,466
United Kingdom	18	3,210	22	4,388
Uruguay	20	4,437	55	5,724
Vietnam, South	13	3,073	--	--
Yugoslavia	--	--	122	12,295
Other	15	3,109	4	566
Total	2,422	532,274	2,406	269,855

[1]Beginning January 1, 1975, ammonium phosphates became diammonium phosphates and ammonium phosphate fertilizers.

[2]Less than 1/2 unit.

Table 14.—U.S. exports of mixed chemical fertilizers, by country

(Thousand short tons and thousand dollars)

Destination	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Austria	--	--	2	147
Bahamas	--	--	6	792
Belgium-Luxembourg	(1)	12	20	1,718
Brazil	7	1,131	15	2,047
Canada	179	10,424	85	10,239
Colombia	45	12,177	(1)	136
Costa Rica	5	763	(1)	19
Dominican Republic	8	1,373	6	867
Ecuador	--	--	3	277
El Salvador	4	560	12	1,326
France	1	100	6	692
Germany, West	4	1,780	8	2,332
Ghana	--	--	11	1,197
Greece	(1)	124	(1)	122
Guatemala	9	1,795	9	1,279
Italy	11	1,266	(1)	16
Japan	4	284	(1)	183
New Zealand	(1)	41	3	330
Nicaragua	5	758	1	216
Panama	12	2,252	5	699
Sweden	--	--	17	1,418
Thailand	9	1,448	24	2,189
United Kingdom	(1)	51	1	118
Vietnam, South	6	634	1	93
Other	15	3,722	7	1,832
Total	324	40,695	242	30,284

[1]Less than 1/2 unit.

Table 15.—U.S. exports of elemental phosphorus, by country

Destination	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Argentina	600	$1,121	--	--
Australia	683	941	249	$311
Belgium-Luxembourg	141	70	303	154
Brazil	65	65	3,353	3,470
Canada	1,638	1,095	4,935	4,761
Chile	22	45	3	1
Denmark	426	515	221	239
Egypt	155	300	--	--
France	--	--	12	5
Germany, West	149	170	--	--
India	441	661	--	--
Israel	26	11	55	24
Italy	112	193	45	45
Japan	3,792	3,263	5,526	6,313
Malaysia	110	149	--	--
Mexico	26,086	25,836	14,232	14,993
Netherlands	--	--	44	20
Switzerland	--	--	16	7
United Kingdom	1,393	2,217	35	36
Other	r6	r7	9	8
Total	35,845	36,659	29,038	30,387

rRevised.

Table 16.—U.S. imports for consumption of phosphate rock and phosphatic materials

(Thousand short tons and thousand dollars)

Fertilizer	1975		1976	
	Quantity	Value	Quantity	Value
Phosphates, crude and apatite	37	1,604	51	2,234
Phosphatic fertilizers and fertilizer materials	147	26,970	47	6,631
Ammonium phosphates, used as fertilizers	303	r50,622	212	26,936
Bone ash, bone dust, bone meal and bones ground, crude or steamed	8	1,108	3	689
Dicalcium phosphate	(1)	46	1	177
Basic slag	(1)	1	--	--
Manures including guano	3	43	(1)	17
Phosphorus	1	1,615	1	1,604
Phosphoric acid	1	231	(1)	149

rRevised.
1Less than 1/2 unit.

WORLD REVIEW

Phosphate rock producing countries have developed beneficiation systems for their particular type of phosphate deposits to raise the P_2O_5 content of the concentrate to levels acceptable for production of phosphoric acid and conversion into fertilizer end products. Dried concentrates were exported from producing countries to support fertilizer industries in areas that do not have phosphate deposits of commercial value. This pattern of production and distribution appeared to be changing as producing companies and countries were increasingly processing the concentrates into phosphoric acid, which can be exported, or utilizing the phosphoric acid to produce monoammonium phosphate, diammonium phosphates, or granular mixed fertilizers for export. The vertical integration of phosphate rock producers, as typified in the United States, was expanding into other phosphate producing countries. Tunisia was the first North African country to produce phosphoric acid at Gabes. Other producers that have traditionally exported phosphate rock planned to establish fertilizer plants; these included Algeria, Morocco, Jordan, and the Republic of South Africa. It now appears that the past practice of processing phosphate rock into fertilizer close to the consuming market in industrialized countries is changing to increased vertical integration of the industry in the countries with a raw material base.

Australia.—BH South Ltd., has outlined phosphate reserves in northwest Queensland totaling over 2 billion tons of phosphate rock with an average 17.1% P_2O_5 content. The deposits are all located in the Georgian Basin. The southern most deposits at Duchess and Ardmore are of immediate interest and Queensland Phosphate Ltd., a wholly-owned subsidiary of BH South Ltd. mined direct shipping ores from the Duchess deposit. The central reserves of the Lady Annie and Lady Jane deposits are north of Mount Isa, and further north are smaller reserves of Highland Plains, Babbling Brooke Hill, Mount O'Conner, Mount Jennifer, Phantom Hills, and Riversleigh.

With completion of the 42-mile railroad extension to the Duchess deposit, shipments from the mine to Townsville were expected to attain a rate of 1 million tons per year in 1976 and 2 million tons per year by 1978. It is not likely that the Lady Annie or Lady Jane deposits will be developed until the early or mid-1980's.[4]

Brazil.—Industrial production of phosphate rock is presently limited to the Serrana S.A. de Mineração installation at the Jacupiranga mine and the Camig plant close to Araxá. Only at the Jacupiranga mine, 250,000 tons per year, is a concentrate suitable for production of phosphoric acid produced. From the Barreiro mine in Araxá rock is ground for direct application, 40,000 tons per year, and the balance, 30,000 tons per year, is sold for reduction in an electric furnace. The following new projects were reported by World Mining.[5] From the Araxá-Barreiro mine, Arafertil-Araxá S.A. Fertilizantes e Productos Quimicos has a lease and plans to produce 550,000 tons per year of 34% P_2O_5 concentrates that will be used in an integrated acid and fertilizer plant. Production is scheduled for 1977. The

4Industrial Minerals. No. 105, June 1976, pp. 26, 31.
5Abib, P. Brazil's Busy Phosphate Industry. World Min., v. 30, No.2, February 1977, pp. 46-49.

Catalão-Metago mine owned by Metais de Goias S.A. is planning to produce from 400,000 to 600,000 tons of 34% P_2O_5 concentrate per year starting in 1978. From the Tapira-Valep mine, Cia. Vale do Rio Paranaiba S.A. intends to produce 1,000,000 tons per year of 36% P_2O_5 concentrate. It is scheduled to start producing in 1978. Preliminary plans are being made by Serrana to develop the Ipanema deposit and others are investigating the potential at Patos de Minas and the northern Pernambuco deposit.

Canada.—In August 1975, International Minerals & Chemical Corp. (Canada) Ltd., reported a phosphate deposit in a carbonatite complex in Cargill Township, Ontario. Drilling and trenching programs were conducted in 1976 to define the orebody.

Egypt.—Phosphate rock production has declined from about 1.6 million tons in 1968 to 559,000 tons in 1974 as the ore deposits at Kusair and Sofaga on the Red Sea were depleted. A new phosphate mine and plant started in February 1976 at Hamrawein and was expected to raise production to pre-1968 levels.[6] Another major event was the completion of a contract to study the feasibility of mining, processing, and shipping phosphates from the Abu Tartur deposits in the south-central part of Egypt west of the Nile River. The deposit, although large, contains, unfortunately, high concentrations of iron, alumina, and clay, and unless procedures are developed to eliminate these problem materials the viability of the deposit remains in doubt.

Greece.—The Institute of Geological and Mineral Research located commercial phosphate rock deposits at Epirus in Northern Greece. The deposit is located about 37 miles north-northwest of Ioannia and preliminary investigations indicate the reserve is 10 million tons of 15% P_2O_5 ore that can be upgraded to plus 30% P_2O_5.[7]

India.—India's first phosphate beneficiation plant at Udaipur went onstream. The plant is designed to process about 660 tons per day of 20% P_2O_5 ore to a product grading 34% P_2O_5. The concentrates will be used to produce phosphoric acid and superphosphates.[8]

Iraq.—Plans to exploit the phosphate rock deposits at Akashat have been made. Work on the mine to produce 3.7 million tons per year of phosphate rock started in 1976. Concurrently, an associated fertilizer complex reportedly will be constructed. Both the mine and initial fertilizer complex are scheduled to start up in mid-1980.[9]

Israel.—Negev Phosphate Co. Ltd. was granted a loan from the Export Import Bank of the United States to assist in financing the expansion of the phosphate mine and beneficiation plant at Nahal Zin. Production will be doubled to 2 million tons per year of concentrates.[10]

Jordan.—The Jordanian Phosphate mines plan to increase phosphate rock production to about 5 million tons per year by expansion of the El-Hassa mine and by opening a new mine at Al-Sheidieh.[11]

Mexico.—Press reports that began in 1974, describing the discovery of a phosphate rock reserve in the Baja California peninsula of Mexico, have continued through 1976. The most recent report indicated the reserve may be 100 million tons. An experimental pilot plant is scheduled to start in 1977 to process rock from the Baja peninsula deposit.[12]

Morocco.—The Office Cherifien des Phosphates has plans to develop a series of new phosphate rock mines, plants, and new port facilities to handle future exports of phosphate rock and solid and liquid phosphate intermediates.

The Khouribga mines are located on the Oulad Abdoun Plateau, between Khouribga and Oued Zem. The two principal open pit mines are Sidi Daoui and Mera el Arech. A new open pit mine, Recette IV, located between Sidi Daoui and Mera el Arech, is being developed. About 30% of Khouribga's production was from underground mines. A new drying plant, similar to the Beni Idir drying plant, was under construction at Oued Zem and will treat the production from Recette IV.

The Youssoufia underground mines are located on the Ganntour plateau. Approximately 70% of the ore was from underground mines and 30% was recovered from surface contour mines. Plans to continue mining the white ore above the water table will continue; however, an increasing quantity of black ore, unoxidized and relatively high in hydrocarbon content, from below the water table will be mined in the future. The black ore will be calcined in fluid bed reactors. The first reactor is scheduled to operate for a full year in 1977.

[6]U. S. Embassy, Cairo, Egypt. Industrial Outlook Report—Minerals. State Department Airgram A-13, Jan. 24, 1977.
[7]U. S. Embassy, Athens, Greece. State Department Airgram 13031, Dec. 9, 1976.
[8]Engineering & Mining Journal. V. 177, No. 4, April 1976, p. 160.
[9]Chemical Engineering. V. 83, No. 4, Feb. 16, 1976, p. 43.
[10]Industrial Minerals. No. 106, July 1976, p. 52.
[11]Work cited in footnote 10.
[12]Industrial Minerals, No. 110, November 1976, p. 42.

A new mine, Benguerir, is scheduled to start production in 1978 or 1979. Initial production will be 2.9 million tons per year. Ultimately, the mine is expected to produce from 10 to 12 million tons per year. The ore from this open pit will be shipped about 56 miles to a beneficiation plant, located on the hill behind the chemical plant, Maroc Phosphore II, near the port of Safi. Salt water will be used to wash the ore. The grade will be increased from 64% bone phosphate of lime (BPL) to 67% BPL with reductions in iron, aluminum, and magnesium oxide content before it is used to produce phosphoric acid.

A new port is to be developed south of Casablanca at Jorf Lasfar to break the shipping bottlenecks that have developed at Casablanca and Safi. These bottlenecks are expected to worsen as production from new mines increases in the next decades. A beneficiation plant is planned at Jorf Lasfar to treat ore mined at Sidi Hajjaj in the early 1980's.

Pakistan.—The Hazara phosphate deposits situated near Abbotabad were drilled and mapped by a British company in 1976. The survey, expected to be completed in 1978, will cover an area of 60 square miles. An appraisal of these deposits will be completed before the design, construction, and training programs for mines and plants are initiated.[13]

Peru.—According to a press release published in Lima on December 17, 1976, Minero Perú and the National Institute of Industry in Spain, through the Empresa Nacional Adaro de Investigaciones Mineras S.A. (ENANDINSA) signed an agreement for the exploitation of the Bayovar phosphate deposit. ENANDINSA will finance and perform the feasibility study over a 10-month period. When the study is completed, a mining company will be formed with Minero Perú on a 49% to 51% basis to develop the deposit. The Spanish will finance the project. The initial production will be 850,000 tons per year of concentrates. A construction schedule of from 3 to 4 years is contemplated.[14]

South Africa, Republic of.—The Phosphate Development Corp. Ltd. (Foskor), commissioned two phosphoric acid facilities which will use phosphate rock from the Phalaborwa deposits. The Federale Kunsmis phosphoric acid plant, an extension of the Bosveld Kunsmis fertilizer complex, started producing in late 1976. The plant capacity is 300,000 tons per year of acid. The Triomf Fertilizer's phosphoric acid plant at Richards Bay went into full production at the end of the year. The capacity is 750,000 tons per year of acid.[15]

Spanish Sahara.—It was reported in midyear that the Office Cherifien des Phosphates made the decision to move phosphate rock from the Bu Craa mine to the port of El Aaiun by trucks after the 62-mile-long conveyor belt was damaged by guerilla attacks. The tonnage moved by trucks was not reported. It was not clear if this effort to replace stocks at El Aaiun was continued for the balance of the year. With only a moderate demand for phosphate rock in 1976, Morocco was able to ship phosphate rock from Casablanca and Safi to meet the commitments for Bu Craa phosphate rock.

Syria.—From a production level of 20,000 tons in 1971, Syria produced 857,000 tons in 1975, but short of the Government's goal of 1.3 million tons. By 1980, Syria plans to produce at the rate of 3 million tons per year. Production was from three plants with a combined capacity of 2 million tons per year. All are located near Palmyra in central Syria. Concentrates are trucked to the port of Tartous and this will continue until a railway is completed in 1978.[16]

Tunisia.—The capacity of Tunisian phosphate mines is projected to increase from a level of 4 million tons per year in 1977 to 6.3 million tons per year in 1980, and 7 million tons per year in 1981. Most of the additional production to achieve the planned increases will come from the underground Sehib mine and Kef Schfair, an open pit mine. Some additional capacity will be created by mechanization of mining systems in the underground mines of Metloui, M'Dilla, Redeyef, M'rata, Moulares, and Kalaa Djerda.

U.S.S.R.—To meet the demand forecast in 1980 for chemical fertilizers and mineral feed supplements, the U.S.S.R. plans to increase production of phosphorus bearing raw materials according to an article by L. Kostandov, the Minister of Chemical Industry of the Soviet Union, published in the weekly paper, Economicheskaya Gazeta, in January 1976. Information about the supply of phosphate rock in the U.S.S.R. is meager; however, from available information, it appears that the Soviet Union will find it increasingly difficult to meet its own phos-

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[13] Mining Journal. V. 287, No. 7360, Sept. 10, 1976, p. 186.
[14] U. S. Embassy, Lima, Peru. State Department Airgram A-182, Dec. 21, 1976.
[15] Industrial Minerals. No. 113, February 1977, p. 12.
[16] U. S. Embassy, Damascus, Syria. State Department Airgram, No. 25, June 16, 1976.

Table 17.— Phosphate rock: World production, by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
North America:			
United States	45,686	48,816	49,241
Mexico	214	311	247
Netherlands Antilles	118	90	59
South America:			
Argentina (guano)	(2)	1	[e]1
Brazil	[r]361	448	[e]540
Chile (guano)	21	15	18
Colombia	11	14	[e]17
Peru	(3)	(3)	--
Venezuela	156	128	88
Europe:			
France	21	20	[e]20
Germany, West	94	90	94
U.S.S.R.[e 4]	24,800	26,600	26,700
Africa:			
Algeria	[r]870	770	550
Egypt	559	445	434
Morocco	21,739	14,934	17,258
Rhodesia, Southern[e]	[r]140	[r]140	140
Senegal:			
Aluminum phosphate	447	222	229
Calcium phosphate	1,623	1,764	1,754
Seychelles Islands (guano)[5]	8	[r e]7	6
South Africa, Republic of[6]	[r]1,564	1,815	1,876
Spanish Sahara	[r]2,535	3,042	190
Togo	2,835	1,279	2,214
Tunisia	[r]4,200	3,845	3,639
Uganda[e]	17	17	17
Asia:			
China, People's Republic of[e]	3,300	3,700	3,700
Christmas Island (Indian Ocean)	1,945	1,534	1,138
India:			
Apatite	13	33	42
Phosphate rock	[r]478	473	676
Israel	1,131	972	704
Jordan	[r]763	1,226	1,876
Korea, North (apatite)[e]	440	500	500
Philippines:			
Guano	15	139	2
Phosphate rock	29	6	13
Syrian Arab Republic	664	945	563
Vietnam[e]	1,300	1,500	1,700
Oceania:			
Australia	2	154	360
Nauru Island	2,522	1,690	832
Ocean Island	619	569	460
Total	[r]121,240	118,254	117,898

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, Belgium, Indonesia, and Tanzania may have continued to produce phosphate rock, and South West Africa produced guano, but output is not officially reported and available information is inadequate for formulation of reliable estimates of output levels.

[2]Less than 1/2 unit.

[3]Revised to none.

[4]Estimate by International Superphosphate Manufacturer's Association on the basis of a marketable product averaging 34.8% P_2O_5; differs with data reported in the U.S.S.R. chapter of Volume III of the Minerals Yearbook which are reported in terms of two products of differing grade.

[5]Exports.

[6]Local sales and exports of phosphate concentrate and direct-sale ore.

phate rock demands. Production from the Kola Apatite Combine, an 86% BPL rock, was equally divided between domestic and export markets. Exports reached a peak of about 7.3 million tons in 1973, and declined in 1974 and 1975. The production target for the Kola Apatite Combine was about 16.9 million tons and, if achieved, was an increase of 4.4 million tons more than was produced in 1970. The target for 1980 is about 20 million tons, an increase of 3.0 million tons over that of 1975. Other sources of phosphate rock will be required to satisfy the demands of the fertilizer industry in the U.S.S.R. It was estimated that 9.7 million tons were produced from the Kara Tau phosphate mines in 1975 and if the U.S.S.R.'s goal of meeting a demand of 37 million tons in 1980 is to be realized, Kara Tau phosphate mines will have to produce an additional 7.9 million tons. Unlike the Kola concentrates that are high-grade and have exceptionally low iron and magnesium oxide analysis, Kara Tau mines supply a low-grade phosphate rock, 28% P_2O_5, that contains 2.2% MgO and 1.5% Fe_2O_3. The low-grade and undesirable impurities are especially troublesome when phosphoric acid is produced and fertilizers manufactured.

TECHNOLOGY

The Albany Metallurgy Research Center of the Federal Bureau of Mines, Albany, Org., conducted programs to improve the recovery of phosphate and byproducts such as fluorine, vanadium, and chromium from phosphate deposits in the Western States. Operating companies in the Western States furnished samples to the Center and these were characterized for potential beneficiation procedures. The samples from nine locations varied in composition and were characterized as low-grade, carbonaceous, and weathered; weathered carbonaceous phosphate shale, partially weathered with interbedded limestone; a pelletal phosphate in a weathered siliceous matrix; and a hard partially liberated, high CaO and MgO content, with carbon ranging from 4% to 14%. A beneficiation process was selected for each sample to obtain an indication of the concentrate grade and recovery from the selected process. The processes ranged from scrubbing and sizing to calcining, grinding, and flotation. A 60-pound-per-hour flotation circuit was set up to develop a combination carbonate-silica flotation process. Methods to improve the liberation of phosphate minerals from unweathered phosphate bearing rock were studied. These included preliminary studies of the effect of leaching and attrition grinding prior to flotation.

The Center also produced feed-grade monocalcium phosphate from Western phosphate concentrates, determined that fluorine retention in triple superphosphate was affected by the iron and aluminum levels in phosphoric acid, and separated vanadium from Western phosphate slime tailings by selective leaching.

Studies to determine the feasibility of producing phosphoric acid from Florida unbeneficiated land-pebble matrix by digesting with sulfuric acid continued. The objective was to minimize phosphate losses and produce a waste product that could be easily used in land reclamation programs and that would not require the impoundment procedures needed to hold waste slimes from Florida washing plants. During the year, filtration rates of matrix-derived phosphoric acid and gypsum residue were progressively improved and approached industry filtration rates normal for acid produced from phosphate concentrates. Excessive aluminum content of matrix-derived phosphoric acid was lowered to levels normally found in commercial acid by liquid-liquid extraction with octyl phenyl phosphoric acid. It was found that iron was concurrently reduced.

The study to determine the effects of reagent additions to high-grade attapulgite slime from the Florida phosphate field was continued at the Tuscaloosa, Ala. Metallurgy Research Center. Organic, inorganic, and commercial reagents were tested. The viscosity, conductivity, and pH of the reagent slime mixtures were measured at different reagent concentrations. After adjustment to different pH levels, the mixtures were centrifuged to simulate a 30-day settling test. The results of these tests were not encouraging as the dewatering rates did not significantly improve. One reagent, polyethylene oxide, was superior when used to flocculate and dewater high-grade attapulgite and montmorillonite slimes as well as Florida phosphate plant slimes. Favorable results were obtained from tests to develop a continuous process to dewater slimes using polyethylene oxide. A phosphate slime of 5% solids and the flocculant solution were combined in a launder, additionally mixed in a low pressure cyclone-type apparatus and fed to a rotating trommel. The flocculated material dewatered rapidly, forming rolls and balls as the material moved down the trommel. The trommel was equipped with a 10-mesh screen to separate the water from the agglomerates that were 25% to 30% solids. At slime feed rates of 1.5 and 3.0 liters per minute, reagent consumption was approximately 1 and 2 kilograms per metric ton respectively. Successful continuous dewatering treatment depends on adequately mixing reagent and slimes and then immediately separating released water from the dewatered solid fraction.

The Center developed a filtration procedure to evaluate the effect of reagents on the settling behavior and mineral composition of slimes. Investigations on static filtration, wicking, and compaction systems to dewater phosphate slimes were continued with emphasis on movement of slimes through a stationary screen barrier.

Characterization studies of the phosphate-bearing Hawthorn Formation limestone continued at the Tuscaloosa Center in cooperation with the Florida State Bureau of Geology. Beneficiation studies of grab samples that contained at least 5% P_2O_5 were made by grinding, scrubbing, and desliming prior to flotation. Acceptable phosphate-grade and recoveries were obtained on some samples with single-stage flotation after dolomite removal.

Platinum-Group Metals

By W. C. Butterman[1]

World mine production of platinum-group metals increased 4% in 1976 compared with that of 1975, to 6 million troy ounces. As in past years, three countries accounted for 99% of the entire output - the Republic of South Africa, the U.S.S.R., and Canada. World demand for platinum-group metals partially recovered from the depressed level of 1975, owing largely to increased demand in the United States, where apparent consumption including industry stock changes rose 24%, to 2.1 million troy ounces. Consumption in Japan remained at about the 1975 level of 1.9 million troy ounces.

In the United States, mine production dropped 68% compared with that of 1975, to 6,116 troy ounces; refinery production, derived almost entirely from secondary materials, and including both toll and nontoll metal, decreased 16%, to 1.09 million troy ounces. Imports increased 47%, to 2.7 million troy ounces, while exports fell 22%, to 0.5 million troy ounces. Sales of metal and metal products to industry increased 22% over those of 1975, to 1.6 million troy ounces, and industry stocks rose 28%, to 1.1 million troy ounces.

[1]Physical scientist, Division of Nonferrous Metals.

Table1.—Salient platinum-group metals[1] statistics

(Troy ounces)

	1972	1973	1974	1975	1976
United States:					
Mine production[2]	17,112	19,980	12,657	18,920	6,116
Value	$1,267,298	$2,103,704	$1,932,203	$2,280,200	$464,527
Refinery production:					
New metal	15,380	19,916	13,234	16,571	7,101
Secondary metal	255,641	265,901	325,216	270,101	215,355
Toll-refined metal	1,361,623	1,039,189	1,088,022	1,016,968	869,664
Total refined metal	1,632,644	1,325,006	1,426,472	1,303,640	1,092,120
Exports (except manufactured goods)	538,994	627,526	835,754	659,885	512,407
Imports for consumption	1,892,184	2,504,181	3,251,311	1,820,284	2,667,059
Stocks Dec. 31: Refiner, importer, dealer	930,853	1,033,124	1,121,806	849,210	1,085,703
Consumption (sales)	1,562,245	1,833,901	1,981,010	r1,308,717	1,603,077
World: Production	4,269,990	5,232,149	r5,769,239	r5,713,660	5,991,720

rRevised.
[1]The platinum group comprises six metals: Platinum, palladium, iridium, osmium, rhodium, and ruthenium.
[2]Recovered from platinum placers and as byproducts of copper refining.

Legislation and Government Programs.— In 1976, as in previous years, U.S. Government inventories of platinum, palladium, and iridium remained unchanged. All three metals were in excess of stockpile goals established in 1973. In October, the Federal Preparedness Agency published revised goals for stockpiled platinum-group metals. The new goals (1,314,000 troy ounces of platinum, 2,450,000 ounces of palladium, and 97,761 ounces of iridium) were several times larger than the pre-October goals, and substantially larger than the inventories.

U.S. motor vehicle emissions standards, as provided for in the Clean Air Act of 1970, have a direct bearing on the amounts of platinum-group metals used as emissions-control catalysts, and even on the combinations of metals used; for example, rhodium may displace palladium in the catalysts if more stringent emissions standards require the use of so-called three-way catalytic converters. Thus, the platinum metals industry followed with interest the months-long debate in the U.S. Congress about future emission standards. Congress adjourned in early October without having amended the Clean Air Act; as the matter stood at yearend 1978 model automobiles will be required to meet emission standards considerably more stringent than those set for the 1977 models.

Table 2.—U.S. Government inventory of platinum-group metals, December 31, 1976

(Troy ounces)

	Platinum	Palladium	Iridium
National stockpile	[1]402,646	[2]507,314	[3]17,002
Supplemental stockpile	49,999	747,680	--
Total	452,645	1,254,994	17,002

[1]Includes 13,043 troy ounces nonstockpile-grade material.
[2]Includes 2,204 troy ounces nonstockpile-grade material.
[3]Includes 12 troy ounces nonstockpile-grade material.

DOMESTIC PRODUCTION

Domestic mine production of platinum-group metals, largely a byproduct of copper mining, decreased 68% in 1976, to 6,116 ounces. The Goodnews Bay Mining Co. placer platinum mine in Alaska, the only domestic deposit mined principally for the platinum-group metals, was shut down early in the year. The Johns-Manville Corp. studied the feasibility of mining its claims in the Beartooth Mountains of southern Montana, but at yearend had not announced whether mine development would proceed. Grade of ore in the mineralized horizon, which had been traced over 24 miles, averaged 0.43 to 0.46 troy ounce of platinum plus palladium per ton, with 0.15% copper plus nickel. The platinum-to-palladium ratio in samples was 1 to 3.5.

U.S. refinery production, including toll-refined metal, fell 16%, to 1.09 million troy ounces; 98% of this was secondary metal. Secondary metal refined on a nontoll basis fell 20%, to 215,355 ounces; toll-refined secondary metal dropped 14% to 859,432 ounces. Refined primary metal totaled 17,333 ounces, most of which was of domestic origin.

Table 3.—Platinum-group metals refined in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
PRIMARY METAL							
Nontoll-refined:							
1972	3,708	10,836	594	173	62	7	15,380
1973	5,560	13,121	957	176	88	14	19,916
1974	4,103	8,634	381	72	38	6	13,234
1975	5,292	10,968	236	44	28	3	16,571
1976	2,748	4,025	244	45	35	4	7,101
Toll-refined:							
1972	54,773	23,752	1,751	111	3,354	478	84,219
1973	32,883	3,972	1,158	102	381	70	38,566
1974	16,293	2,784	742	96	185	7	20,107
1975	14,619	2,002	373	15	164	1	17,174
1976	8,676	1,063	355	39	95	4	10,232
SECONDARY METAL							
Nontoll-refined:							
1972	75,942	162,718	4,393	149	11,390	1,049	255,641
1973	94,884	150,019	6,785	20	11,561	2,632	265,901
1974	95,999	213,416	3,494	6	11,127	1,174	325,216
1975	103,623	149,552	2,300	44	13,683	899	270,101
1976	64,901	134,747	3,921	10	8,058	3,718	215,355
Toll-refined:							
1972	787,697	431,248	7,717	1,520	44,065	5,157	1,277,404
1973	581,005	373,396	3,395	1,292	36,865	4,670	1,000,623
1974	654,156	365,779	3,465	1,447	36,196	6,872	1,067,915
1975	541,930	383,501	10,424	1,263	43,137	19,539	999,794
1976	494,069	311,000	6,507	1,429	34,035	12,392	859,432
1976 TOTALS							
Total primary refined	11,424	5,088	599	84	130	8	17,333
Total secondary refined	558,970	445,747	10,428	1,439	42,093	16,110	1,074,787
Grand total refined	570,394	450,835	11,027	1,523	42,223	16,118	1,092,120

CONSUMPTION AND USES

Sales of platinum-group metals to domestic industries increased 22% over those of 1975, to 1.6 million troy ounces. Sales of five of the six metals increased by the following percentages: Platinum, 22%; palladium, 21%; iridium, 11%; rhodium, 11%; and ruthenium, 100%. Osmium sales declined 26%. Of particular importance were sales of platinum and palladium to the automotive industry for use in emission-control catalysts; these were nearly double the 1975 level, owing partly to an increase in automobile production and partly to the depletion of the large inventories of platinum and palladium held by the automobile manufacturers in early 1975. The automotive industry accounted for more than 50% of platinum sales, and more than 25% of palladium sales; thus, for the third consecutive year, it was the largest domestic purchaser of platinum-group metals, accounting for 42% of total sales. It was followed, in order of importance, by the electrical industry (18%), the chemical industry (15%), the dental-medical industry (10%), the petroleum refining industry (4%), and other industries (11%). Platinum sales comprised 53% of total sales, followed by palladium (41%), rhodium (3%), ruthenium (3%), iridium (less than 1%), and osmium (less than 1%).

The uses of the platinum-group metals in 1976 were related to their outstanding catalytic properties, refractoriness, and resistance to chemical corrosion. The patterns of usage of the two principal metals, shown in figure 1, were similar to the patterns of recent years, except that catalyst use of palladium displaced electrical use as the most important end use of that metal.

Table 4.—Platinum-group metals[1] sold to consuming industries in the United States

(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1972	545,299	876,024	37,754	2,397	46,095	54,676	1,562,245
1973	658,533	1,012,484	30,676	1,629	73,515	57,064	1,833,901
1974	943,689	886,063	22,778	1,723	61,602	65,155	1,981,010
1975:							
Automotive	273,000	97,000	--	--	--	--	370,000
Chemical	148,813	142,975	2,559	414	15,440	5,457	315,658
Dental and medical	17,097	114,970	54	669	41	144	132,975
Electrical	73,624	132,247	1,969	--	8,252	10,638	226,730
Glass	33,813	17,633	207	--	4,471	183	56,307
Jewelry and decorative	22,900	23,026	401	--	4,932	1,156	52,415
Petroleum	107,988	r1,755	3,587	--	114	(2)	r113,444
Miscellaneous	21,318	11,942	366	1	3,598	3,963	41,188
Total	698,553	r541,548	9,143	1,084	36,848	r21,541	r1,308,717
1976:							
Automotive	480,965	194,496	--	--	391	--	675,852
Chemical	83,560	128,229	1,351	66	19,225	5,834	238,265
Dental and medical	26,858	139,279	233	729	75	140	167,314
Electrical	89,319	152,312	6,368	--	9,062	29,728	286,789
Glass	41,683	2,989	288	--	3,828	93	48,881
Jewelry and decorative	23,371	5,700	1,024	--	5,170	2,942	38,207
Petroleum	59,103	7,291	395	--	1	--	66,790
Miscellaneous	46,246	26,766	458	2	3,123	4,384	80,979
Total	851,105	657,062	10,117	797	40,875	43,121	1,603,077

r Revised.
[1] Comprises primary and nontoll refined secondary metals.
[2] Revised to zero.

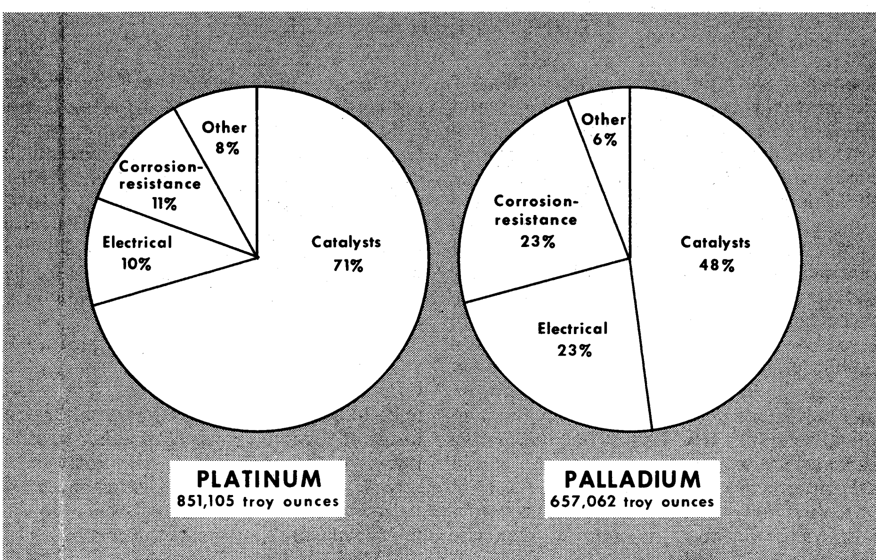

Figure 1.—Uses of platinum and palladium in 1976.

STOCKS

Stocks of platinum-group metals held by refiners, importers, and dealers increased 28% in 1976 compared with those of 1975. Rhodium stocks fell 11% and osmium stocks fell 30%, but stocks of the other four metals increased, as follows: Platinum (27%); Palladium (37%); iridium (11%); ruthenium (5%). It should be noted that these are partial industry stocks, since the Bureau of Mines does not collect inventory data from end users of the platinum-group metals, some of whom may hold sizable inventories. In addition, there were the Government stockpiles of platinum, palladium, and iridium.

Table 5.—Refiner, importer, and dealer stocks of platinum-group metals in the United States, December 31[1]

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1972	426,611	405,793	14,987	82	56,967	26,413	930,853
1973	446,522	493,078	14,813	327	51,504	26,880	1,033,124
1974	532,675	478,210	18,159	869	55,791	36,102	1,121,806
1975	420,770	335,621	18,276	627	53,847	20,069	849,210
1976	536,318	459,765	20,318	439	47,769	21,094	1,085,703

[1]Includes metal in depositories of the New York Mercantile Exchange; on Dec. 30, 1976, this comprised 172,100 troy ounces of platinum and 20,500 troy ounces of palladium.

PRICES

The producers' price for platinum was quoted at the beginning of the year at $155 per troy ounce, was raised to $165 in June, to $170 in July, and then lowered to $162 at the beginning of November. The producers' palladium price began the year at $50 per troy ounce, was lowered to $40 in April, raised to $45 in May, and to $55 in June. The rhodium price at the beginning of the year was $300 per troy ounce, and was increased to $350 at the beginning of July, and to $400 on July 20. The iridium price went from $400 per troy ounce to $300 at the beginning of April. Producers' ruthenium and osmium prices remained unchanged throughout the year at $60 and $200 per troy ounce, respectively.

Dealers' prices for platinum and palladium remained below producers' prices, except for a few weeks near midyear. Dealers' prices for rhodium and iridium, which began the year far below producers' prices, began to rise in the second quarter and were above producers' prices in the third quarter before falling below producers' prices again in the fourth quarter. Dealers' prices for ruthenium and osmium remained, as in recent years, below producers' prices all year. Average prices for the year, calculated at the low ends of the ranges of weekly averages published by Metals Week, follow:

	Producer (per troy ounce)	Dealer (per troy ounce)
Platinum	$161.73	$153.38
Palladium	50.93	47.29
Iridium	325.00	271.09
Osmium	200.00	129.42
Rhodium	347.50	309.68
Ruthenium	60.00	36.55

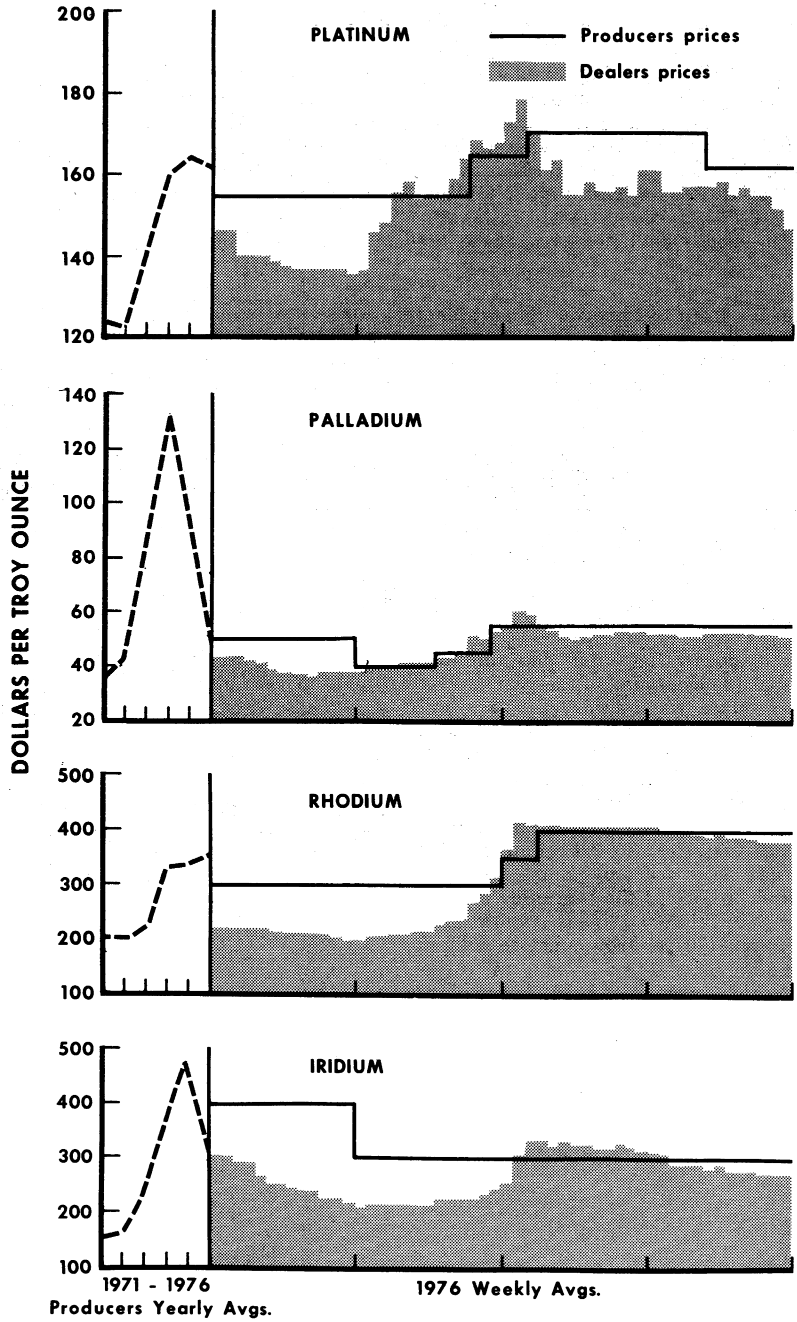

Figure 2.—Prices of four platinum-group metals.

FOREIGN TRADE

Exports of unwrought and semimanufactured platinum-group metals decreased 22% in 1976, to 512,407 troy ounces; about 225,000 troy ounces of this, or 44%, was platinum. Valued at $53 million, exports went mainly to the United Kingdom (26%), Japan (23%), and West Germany (15%).

Imports, on the other hand, increased 47% in 1976, to 2.7 million troy ounces, valued at $292 million. Of total imports, including estimates of metal in composite import classes, 44% was platinum and 48% was palladium. Compared with 1975 levels, Platinum imports increased 16% and palladium imports nearly doubled. The principal sources of platinum-group imports were the Republic of South Africa, which supplied 47% of the imports directly and originated a substantial part of the 17% of imports that came from the United Kingdom; and the U.S.S.R., which supplied 24% of the imports directly and an unknown additional quantity via European countries. Imports of each metal were estimated as follows:

	Thousand troy ounces
Platinum	1,185
Palladium	1,284
Iridium	31
Osmium	4
Rhodium	74
Ruthenium	89
Total	2,667

Table 6.—U.S. exports of platinum-group metals, by country

Year and destination	Platinum-group metals				Platinum, unworked or partly worked				Platinum-group metals, except platinum, unworked or partly worked				Total	
	Ores and concentrates		Waste, scrap, and sweepings		Not rolled		Rolled		Not rolled		Rolled			
	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)
1975:														
Australia	--	--	--	--	1,112	$188	13	$4	655	$40	--	--	1,780	$232
Belgium-Luxembourg	--	--	30,889	$2,847	920	184	--	--	991	144	12	$1	32,812	3,176
Brazil	119	$11	--	--	940	167	11	2	4,368	371	913	56	6,351	607
Canada	2,341	147	328	38	7,065	1,148	246	49	29,293	3,358	334	19	39,607	4,759
France	--	--	468	46	3,543	557	10	3	5,334	403	929	221	10,284	1,230
Germany, West	1,832	252	23,773	2,103	23,226	5,395	764	149	84,205	8,566	1,954	253	135,754	16,718
Israel	--	--	--	--	--	--	--	--	--	--	4,420	143	4,420	143
Italy	--	--	--	--	50	10	--	--	8,937	438	11,400	401	20,387	849
Japan	--	--	--	--	106,068	17,055	19,444	2,952	27,126	4,008	16,136	1,463	168,774	25,478
Netherlands	--	--	--	--	24,831	3,863	42	8	3,470	507	46	2	28,389	4,380
South Africa, Republic of	--	--	5,025	686	--	--	--	--	50,697	8,217	--	--	55,722	8,903
Switzerland	48	25	--	--	33,549	5,213	--	--	8,673	688	968	59	43,238	5,985
United Kingdom	3,371	293	23,265	2,353	59,428	9,990	10	4	10,229	702	1,353	63	97,656	13,405
Other	21	6	174	22	3,520	641	4	1	8,411	559	2,581	420	14,711	1,649
Total	7,732	734	83,922	8,095	264,252	44,411	20,544	3,172	242,389	28,001	41,046	3,101	659,885	87,514
1976:														
Australia	--	--	--	--	1,903	254	--	--	1,586	76	--	--	3,489	330
Belgium-Luxembourg	--	--	48,910	2,579	4,040	780	--	--	392	8	--	--	53,342	3,367
Canada	287	54	383	27	12,604	2,162	14	5	33,946	2,613	620	30	47,854	4,891
France	--	--	1,028	116	2,657	445	8	3	6,155	416	178	5	10,026	985
Germany, West	3,167	290	14,288	1,599	11,550	1,930	441	80	43,013	3,349	2,257	351	74,716	7,599
Italy	--	--	--	--	--	--	--	--	4,280	176	2,727	59	7,007	235
Japan	186	4	--	--	66,095	10,263	8,827	1,333	38,715	3,917	5,034	371	118,857	15,888
Mexico	--	--	--	--	199	40	--	--	2,432	202	--	--	2,631	242
Netherlands	--	--	451	84	52	12	19	6	2,475	291	100	35	3,097	428
South Africa, Republic of	--	--	5,964	916	--	--	--	--	5,226	872	--	--	11,190	1,788
Switzerland	296	41	6,258	394	24,703	3,957	--	--	1,518	93	10	1	32,785	4,486
Taiwan	--	--	--	--	8	5	--	--	5,697	313	280	9	5,985	327
United Kingdom	1,772	148	103,710	9,364	3,857	589	551	76	21,131	881	1,230	50	132,251	11,108
U.S.S.R.	--	--	--	--	--	--	--	--	1,603	358	--	--	1,603	358
Venezuela	--	--	--	--	4	1	--	--	1,306	23	160	7	1,470	31
Other	--	--	154	7	1,369	294	50	10	3,786	287	745	92	6,104	690
Total	5,708	537	181,146	15,086	129,041	20,732	9,910	1,513	173,261	13,875	13,341	1,010	512,407	52,753

Table 7.—U.S. imports for consumption of platinum-group metals, by country

Year and country	Unwrought (troy ounces): Platinum grains and nuggets	Platinum sponge	Palladium	Iridium	Osmium	Osmiridium	Rhodium	Ruthenium	Unspecified combinations[1]	Platinum-group metals from precious metal ores	Sweepings, waste and scrap
1975	19,253	567,466	409,862	14,419	1,121	6,564	80,197	[2]16,535	227,037	35	116,523
1976:											
Australia	--	--	--	--	--	--	--	--	--	--	6,040
Belgium-Luxembourg	--	1,077	1,000	--	--	--	--	--	--	--	27,491
Canada	65	1,334	16,141	294	--	--	1,851	4,421	--	--	65,946
Colombia	--	--	--	--	--	--	--	--	14,051	--	4,150
Costa Rica	--	--	--	--	--	--	--	--	--	--	1,344
Finland	--	--	--	--	--	--	--	--	--	--	1,746
France	--	5,873	3,363	100	--	--	628	--	--	--	21
Germany, West	--	13,245	15,282	1,073	250	--	1,548	1,000	--	--	1,804
Italy	--	3,500	--	--	--	--	--	--	--	--	--
Japan	--	8,170	260	1,553	--	--	--	--	9,881	--	--
Mexico	--	--	--	--	--	--	--	--	--	--	20,322
Netherlands	--	1,000	2,436	--	--	--	--	1,050	--	--	1,445
Norway	--	8,369	9,304	--	--	--	--	--	4,637	--	1,199
Peru	--	1,900	750	--	--	--	--	--	--	--	--
Portugal	--	6,000	--	--	--	--	--	--	--	--	--
South Africa, Republic of	338	686,960	439,170	12,225	809	--	26,208	50,574	7,936	--	2,008
Sweden	--	550	650	--	--	--	--	--	--	--	6,479
Switzerland	--	1,000	8,087	--	--	--	200	--	500	--	--
U.S.S.R.	--	955	370,830	--	--	--	12,506	--	161,881	--	--
United Kingdom	193	164,115	124,773	2,613	200	6,685	19,056	18,628	17,200	--	4,745
Yugoslavia	--	--	2,314	--	--	--	--	--	458	--	--
Other	--	--	--	321	--	--	263	--	72	--	2,033
Total	596	904,048	994,360	18,179	1,259	6,685	62,260	75,673	216,616	--	146,773

See footnotes at end of table.

Table 7.—U.S. imports for consumption of platinum-group metals, by country—Continued

Year and country	Semimanufactured (troy ounces)								Platinum-group metals in materials not elsewhere specified (troy ounces)	Total	
	Platinum	Palladium	Iridium	Osmium	Osmiridium	Rhodium	Ruthenium	Unspecified combinations[1]		Quantity (troy ounces)	Value (thousands)
1975	96,630	144,240	941	--	--	1,832	408	12,867	104,354	1,820,284	$272,823
1976:											
Australia	240	--	--	--	--	--	--	--	--	6,280	1,258
Belgium-Luxembourg	104	1,744	--	--	--	--	--	--	--	31,416	5,728
Canada	221	632	--	--	--	421	1,000	--	1,322	93,648	9,082
Colombia	--	--	--	--	--	--	--	--	--	18,201	2,428
Costa Rica	--	--	--	--	--	--	--	--	--	1,344	216
Finland	--	--	--	--	--	--	--	--	--	1,746	193
France	2,000	--	--	--	--	--	--	--	--	11,985	1,561
Germany, West	789	1,023	--	--	--	--	--	--	--	36,014	4,580
Italy	1,909	--	--	--	--	--	--	--	--	5,409	891
Japan	--	--	--	--	--	--	--	--	--	19,864	3,326
Mexico	--	--	102	--	--	--	--	--	--	20,424	1,517
Netherlands	199	--	--	--	--	--	--	--	--	6,130	569
Norway	--	--	--	--	--	--	--	--	4,594	28,103	3,225
Peru	--	--	--	--	--	--	--	--	--	2,650	364
Portugal	--	--	--	--	--	--	--	--	--	6,000	1,077
South Africa, Republic of	6,696	4,949	--	--	--	--	--	9	3,787	1,241,669	145,167
Sweden	--	--	--	--	--	--	--	--	--	7,679	1,397
Switzerland	2,510	344	--	--	--	1,000	--	--	--	13,641	1,237
U.S.S.R.	49,475	56,272	--	--	--	193	--	--	--	652,112	55,665
United Kingdom	31,028	62,379	2,781	--	--	250	--	547	--	455,193	51,117
Yugoslavia	482	1,608	--	--	--	--	--	--	--	4,862	355
Other	--	--	--	--	--	--	--	--	--	2,689	583
Total	95,653	128,951	2,883	--	--	1,864	1,000	556	9,703	2,667,059	291,536

[1]Contains not less than 90% platinum by weight.
[2]Estimated by the Bureau of Mines.

Table 8.—Imports of platinum-group metals, in 1976, by source

(Percent of total imports)

Source	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
South Africa, Republic of	60	35	40	22	37	57	47
U.S.S.R.	12	37	10	--	22	11	24
United Kingdom	18	15	27	71	27	21	17
Japan	1	(1)	6	--	(1)	(1)	1
Other	9	13	17	7	14	11	11

[1]Less than 1/2 unit.

WORLD REVIEW

World mine production of the platinum-group metals increased about 4% in 1976, to 6 million troy ounces. The U.S.S.R. mined 2.8 million troy ounces and the Republic of South Africa mined 2.7 million troy ounces; together they accounted for 92% of world output. Canada mined 430,000 troy ounces, or 7% of the world total. The United States and six other countries accounted for the remaining 1% of world production.

U.S. mine production, largely as a byproduct of copper mining, was 6,116 troy ounces in 1976, compared with 18,920 troy ounces in 1975. The output of Colombia's river placers was 26,000 troy ounces, and small quantities of platinum-group metals were derived from placer mining in Ethiopia, and as byproducts of copper and nickel mining in Japan, Finland, the Philippines, and Australia.

Canada.—Canadian output of platinum-group metals increased 8%, to 430,000 troy ounces. The metals were byproducts of nickel-copper mining in Ontario and Manitoba, and were produced by Inco, Ltd., and Falconbridge Nickel Mines, Ltd. Texasgulf, Inc., after considerable exploratory drilling, dropped its option on the Lac des Iles platinum-group metals prospect near Thunder Bay, Ontario. However, drilling was resumed late in the year by the owner of the property, Boston Bay Mines, Ltd.[2]

South Africa, The Republic of.—The Republic of South Africa produced 2.7 million troy ounces of platinum-group metals in 1976, including about 61% of the world's newly-mined platinum, 27% of its palladium, 58% of its rhodium, 35% of its iridium, 46% of its ruthenium, and a substantial part of its osmium. Except for small quantities of osmiridium recovered as a byproduct of gold mining, all of the platinum-group metals were mined as principal products from several mines in the Merensky Reef, an extensive horizon in Transvaal Province containing more than half of the world's resources of platinum-group metals. Estimated production of the four companies that mined the Reef are as follows: Rustenburg Platinum Mines, Ltd., 1,550,000 troy ounces; Impala Platinum, Ltd., 1,000,000 troy ounces; Western Platinum, Ltd., 130,000 troy ounces; Atok Platinum Mines, Pty., Ltd., 30,000 troy ounces. The two largest companies decreased production in early 1975, to adjust to a sluggish market in that year, but by about mid-1976, both companies began to increase production. As a result, South African production in 1976 was modestly higher than in the preceding year.

U.S.S.R.—The U.S.S.R. produced an estimated 2.8 million troy ounces of platinum-group metals in 1976, accounting for 31% of the world's platinum, 66% of its palladium, 34% of its rhodium, 55% of its iridium, and 44% of its ruthenium. A small fraction of the metal came from gold-platinum placer deposits in the central Urals, but most was a byproduct of nickel-copper mining in the Norilsk-Talnakh region of northwestern Siberia, and the Petsamo-Monchegorsk region of the Kola Peninsula.

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[2]The Northern Miner. Deep Hole for Boston Bay at Lecdes Iles Palladium. V. 62, No. 32, Oct. 21, 1976, p. 27.
—. Texasgulf Dropping Its Boston Bay Option. V. 62, No. 2, Mar. 25, 1976, p. 1.

Table 9.—Platinum-group metals: World production by country[1]

(Troy ounces)

Country	1974	1975	1976[p]
Australia:			
Palladium, metal content, from nickel ore[e]	860	1,400	1,500
Platinum, metal content, from nickel ore[e]	260	[r]430	470
Canada: Platinum-group metals from nickel ore	384,618	399,218	429,999
Colombia: Placer platinum	21,094	22,114	26,000
Ethiopia: Placer platinum	230	162	[e]200
Finland: Platinum-group metals from copper ore[e]	650	600	640
Japan[2]:			
Palladium from nickel and copper ores	11,104	13,915	18,089
Platinum from nickel and copper ores	4,101	5,486	8,706
Philippines:			
Palladium from nickel/cobalt ores	2,315	836	--
Platinum from nickel/cobalt ores	1,350	579	--
South Africa, Republic of: Platinum group metals from platinum ores[e] [3]	[r]2,830,000	[r]2,600,000	2,700,000
U.S.S.R.: Placer platinum and platinum-group metals recovered from nickel/copper ores[e]	2,500,000	2,650,000	2,800,000
United States: Placer platinum and platinum-group metals from gold and copper ores	12,657	18,920	6,116
Total[4]	[r]5,769,239	5,713,660	5,991,720

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Excludes metal refined in Norway and the United Kingdom derived from Canadian and South African ores.
[2]Japanese figures exclude metal recovered from Philippine ores.
[3]Includes osmiridium from gold ores estimated at 2,500 troy ounces annually.
[4]Total excludes metal refined in West Germany and which is believed to be derived from imported ores. Production is as follows in troy ounces: 1974—4,115; 1975—3,601; 1976—2,283.

TECHNOLOGY

Research continued on automotive emission-control devices in 1976, although on a smaller scale than in previous years, it appeared that the U.S. Congress would amend the automotive emissions standards. The new standards were expected to result in the use of the three-way converter, which employs a platinum-rhodium catalyst to act simultaneously on carbon monoxide, unburned hydrocarbons, and nitrogen oxides. The major domestic and foreign automobile companies tested various models of the three-way converter, and limited numbers were installed on production cars sold in California. Much of the research was aimed at reducing the rhodium content of the catalyst; unless the rhodium-platinum ratio in the catalyst could be brought down to the rhodium-platinum ratio in South African ores, it would be difficult to obtain enough rhodium to equip all American cars with three-way converters.

Higher numbers of automobiles equipped with catalytic converters necessitate the increased production of unleaded gasoline. This requires the achievement of higher unleaded (clear) octane numbers, a process in which catalytic reforming plays an important part. However, yield of gasoline and octane rating are inversely related in reforming. Operating at low pressures lessens the dropoff in yield, but it also increases the coking rate of the catalyst. One solution to the problem of maintaining catalyst activity in an economic, uninterrupted fashion was reported by UOP Inc. In UOP's Continuous Platforming system, small quantities of catalyst are removed from the reactor, reactivated, and returned to the reactor in an essentially continuous manner. Continuous platformers have been in operation since 1971, and by 1976, six units were onstream. Several dozen more were in various stages of design and construction.[3]

Certain water-insoluble organic ruthenium complexes were found to be effective, on a laboratory scale, in splitting water through a photoinduced electron-transfer mechanism. The work was of considerable interest as a potential means of using solar energy to produce a highly desirable fuel, hydrogen. The reaction was believed to be truly catalytic, with an overall efficiency somewhere between 10% and 50%.[4]

Platinum metal catalysts, designed to support the thermal combustion of a variety of fuels, such as low-Btu gas, were announced. They were considered to be of potential use in transportation, home heating, power generation, and other stationary and mobile applications.

Printed thermocouples, formed by applying newly developed precious metal inks

[3]Pollitzer, E.C. Continuous Platforming. Platinum Metals Rev., v. 20, No. 1, January 1976, pp. 2-6.
[4]Chemical & Engineering News. Ruthenium Complexes Aid Hydrogen Process. V. 54, No. 23, May 31, 1976, pp. 17-21.

to ceramic substrates, were developed. The gold-palladium:platinum-palladium thermocouples are usable in air up to 850°C, and are similar to Chromel:Alumel wire thermocouples in electromotive force output. They were said to be rugged, to give rapid response, and to have excellent long-term stability. Continued development of other temperature-measuring devices resulted in new rhodium-iridium thermocouples that are accurate to 2100°C; in other thermocouple alloys of platinum, palladium, iridium, and gold, designed to replace base metal thermocouples in the temperature ranges up to 120°C; and in a new rhodium versus 0.5% iron resistance thermometer wire which extends the measurement of cryogenic temperatures down to 0.35°K.[5]

The platinum-rhodium gauzes that catalyze the oxidation of ammonia to nitric acid in modern nitric acid plants ordinarily remain in service several months. Occasionally, however, a gauze pack becomes inactive prematurely, and cannot be reactivated by cleaning in solvents or acid. A study of normal and inactive gauzes by scanning electron microscopy and X-ray diffraction, reported in 1976, showed that the surfaces of inactive gauzes were covered with crystalline rhodium oxide. It was inferred, from earlier work, that gauzes become passivated by a rhodium oxide layer when, because of error in temperature control or calibration, they are operated below design temperature.[6]

An account was published of experimental studies confirming that reduction of refractory metal oxides by carbon monoxide, hydrogen, carbon, and organic vapors is promoted by the presence of platinum-group metals, especially platinum and palladium. These reactions are of importance in industrial situations where platinum metals and refractory oxides are in close proximity or physical contact at high temperatures; under these circumstances, accidental or temporary exposure to reducing flames or organic impurities can lead to rapid destruction of the platinum metal and refractory material. The studies yielded thermodynamic data on the reduction reactions, and suggested the possibility of brazing other metals to refractory oxides by use of a platinum-containing brazing alloy.[7]

The unmanned Viking lander that reached Mars in July contained a small gas chromatograph/mass spectrometer for analyzing the gases emitted by pyrolyzed samples of Martian soil. An important component of the instrument was a unique electrolytic pump used to remove the hydrogen carrier gas from the sample gases before their entry into the spectrometer. The pump was essentially an electrolytic cell consisting of palladium-silver alloy tubing immersed in molten sodium hydroxide electrolyte. Hydrogen was ionized in the anodic coil, after which it diffused through the palladium-silver wall into the electrolyte, and flowed to the cathodic coil, where, after reduction, it diffused into the tubing and was discharged to the atmosphere as molecular hydrogen.[8]

The rate at which sputtered coatings of the platinum metals may be satisfactorily deposited reportedly was increased more than an order of magnitude by the invention of a new system that employs a magnetic field to trap secondary electrons emitted from the target. The entrapment increases the sputtering rate by preventing secondary electrons from bombarding, and thus heating, the substrate. At the same time, it uses the secondary electrons to enhance ionization in the sputtering gas.[9]

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[5]American Metal Market. Platinum. V. 83, No. 178, Sept. 10, 1976, pp. 10-22.

[6]Spencer, F., and W. Hohmann. Rhodium-Platinum Gauzes for Ammonia Oxidation. Platinum Metals Rev., v. 20, No. 1, January 1976, pp. 12-20.

[7]Ott, D., and C. Raub. The affinity of the Platinum Metals for Refractory Oxides. Platinum Metals Rev., v. 20, No. 3, July 1976, pp. 79-85.

[8]Platinum Metals Review. The Viking Mission to Mars. V. 20, No. 3, July 1976, pp. 92-93.

[9]Platinum Metals Review. High-Rate Sputtering of the Platinum Metals. V. 20, No. 3, July 1976, pp. 94-95.

Potash

By Richard H. Singleton[1]

Apparent consumption of potash in the United States increased 20% in 1976 to 6.15 million tons of K_2O equivalent. The increased demand was met primarily by a 21% increase in imports, to 4.59 million tons of K_2O, 97% of which came from Canada. Domestic production continued to decline, decreasing 4% in 1976 to 2.40 million tons and producers' inventories decreased by 0.10 million tons to 0.52 million tons of K_2O. Sales by domestic producers increased 19% in volume to 2.5 million tons of K_2O and 8% in value to $203 million. Exports increased 21% to 0.95 million tons.

U.S. consumption was stimulated by price reductions which occurred during the summer months. The average 1976 price for domestic potash, f.o.b. mine, based on actual sales, was about 10% lower than in 1975.

Sulfates of potash, including purchased muriate that was converted to sulfate, comprised 16% of total U.S. production on a K_2O basis, compared with 15% in 1975. The average 1976 price, based on actual sales, for sulfate of potash was about 9% higher than the 1975 price.

Total sales of potash to U.S. customers by North American producers increased 24% to about 6.0 million tons of K_2O. Sales of granular grade increased 38% to 1.64 million tons, sales of coarse grade increased 25% to 2.27 million tons, and sales of standard grade increased only 10% to 1.17 million tons.

Modest capacity expansions by three producers and a contraction of capacity by one producer in the Carlsbad, N. Mex., area were reported. One mine in the Carlsbad

[1]Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient statistics on potash

(Thousand short tons and thousand dollars)

Item	1972	1973	1974	1975	1976
United States					
Production	4,738	4,684	4,716	4,577	4,416
K_2O equivalent	2,659	2,603	2,552	2,501	2,400
Sales by producers	4,653	5,174	4,708	3,819	4,600
K_2O equivalent	2,618	2,865	2,545	2,094	2,500
Value at plant[1]	$104,680	$123,738	$158,607	$187,857	$202,635
Average value per ton	$22.50	$23.92	$33.69	$49.19	$44.05
Exports[2]	1,353	1,579	1,415	1,419	1,670
K_2O equivalent	764	889	787	r779	945
Value[3]	$45,858	$57,997	$66,175	$92,701	$91,887
Imports for consumption[2]	4,979	6,046	7,245	6,271	7,578
K_2O equivalent	2,961	3,587	4,326	r3,797	4,594
Value[4]	$119,666	$145,693	$236,747	$267,248	$344,229
Apparent consumption[5]	8,279	9,641	10,538	8,671	10,508
K_2O equivalent	4,815	5,563	6,084	r5,112	6,149
Yearend producers' stocks, K_2O equivalent	468	206	212	619	519
World production, marketable, K_2O equivalent	20,841	r23,310	r26,228	r27,352	26,876

rRevised.
[1]F.o.b. mine.
[2]Excludes potassium chemicals and mixed fertilizers.
[3]F.a.s. U.S. port.
[4]U.S. customs value.
[5]Measured by sales plus imports minus exports.

area was opened and another was closed. Two producers announced increases in sylvite ore reserves, both in zone 1 of the Carlsbad deposits. Two organizations began exploratory drilling in Montana and North Dakota, and a preliminary evaluation indicated that solution mining at depths of 7,000 to 9,000 feet was technically feasible. A U.S. potash producer began exploratory drilling in Utah with an intent of solution mining at depths of around 6,000 feet.

Five U.S. producers were indicted by the U.S. Department of Justice for allegedly restricting potash trade and production and fixing prices. The trial was scheduled to begin in January 1977.

Exploratory drillings were made in the Carlsbad area to evaluate mineral resources in the region of a potential salt-bed repository for nuclear reactor wastes. An economic-engineering analysis was begun in late 1976 by the Federal Bureau of Mines to determine whether the repository would significantly reduce reserves of potash in the area.

Potash production in Canada, all muriate, decreased to 5.51 million tons and producers' inventories also decreased. Overseas exports decreased to 0.99 million tons whereas exports to the United States increased to 4.44 million tons. Domestic consumption in Canada increased to approximately 0.27 million tons. The government of the Province of Saskatchewan began acquisition of the Province's potash industry by purchase of a mine and mill from Duval Corp. of Canada. Appraisal of two other mine-mill units was completed, and appraisal of a third began. The government's announced intention was to acquire control of 50% of Saskatchewan's potash industry by 1979. Litigation continued in Saskatchewan courts regarding the legality of the Province's reserve tax and other Provincial taxes.

World production of potash decreased 2% to 26.9 million tons of K_2O equivalent. Production decreases in North America and in Western Europe were not quite counteracted by production increases in Eastern Europe. Producers' inventories remained high in much of Western Europe because demand was lower than anticipated.

The Bureau of Mines continued potash beneficiation experiments aimed primarily at improving potash recoveries from high-clay sylvite ores.

DOMESTIC PRODUCTION

U.S. production of marketable potash salts decreased 4% to 2.40 million tons of K_2O equivalent. Sulfates of potash, including purchased muriate that was converted to sulfate, comprised 16% of total production compared with 15% in 1975. Production of standard-grade muriate decreased 8% to 0.99 million tons of K_2O, whereas output of coarse grade increased 10%. Production of granular grade remained constant.

In New Mexico, the source of 83% of U.S. production in 1976, nine underground mines were operated near Carlsbad by AMAX Chemical Corp., Duval Corp. (two mines), International Minerals & Chemical Corp., Kerr-McGee Chemical Corp., Mississippi Chemical Corp., National Potash Co. (two mines), and Potash Co. of America. The average K_2O content of ores mined in New Mexico declined to 14.8% in 1976 from 15.2% in 1975. These ores had contained an average of 17.5% K_2O in 1966.

Three companies produced potash in Utah: Texasgulf, Inc., working an old room-and-pillar mine near Moab by solution mining; Great Salt Lake Minerals & Chemicals Corp., producing potassium sulfate from brines from the Great Salt Lake; and Kaiser Aluminum & Chemical Corp., treating near-surface brines near Wendover. In California, potash continued to be produced from Searles Lake brines by the Kerr-McGee Chemical Corp.

AMAX Chemical Corp. undertook capital programs at its New Mexico facility to somewhat expand ore reserves and increase production capacity.

Duval Corp. opened its North mine in New Mexico in March and thereby planned to increase total muriate production capacity to 210,000 tons of K_2O equivalent by late 1977.

Great Salt Lake Minerals & Chemicals Corp. developed a proprietary process for converting purchased muriate of potash into sulfate of potash; this was one of the steps taken to reduce dependency of output on Utah weather. Wet weather, which had diluted brine in the Great Salt Lake and in the solar evaporation ponds, abated in 1976. A unique commercial flotation process for concentrating schoenite, prior to conversion to sulfate of potash, went onstream in January 1976.

Table 2.—Domestic production, sales, and stocks of potash

(Thousand short tons and thousand dollars)

Item	Production				Sold or used						Stocks end of 6-month period			
	Gross weight		K_2O equivalent		Gross weight		K_2O equivalent		Value[1]		Gross weight		K_2O equivalent	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
January-June:														
Muriate of potash, 60% K_2O minimum														
Standard	888	882	539	536	664	918	404	559	30,797	38,687	389	544	236	329
Coarse	415	367	253	224	353	407	215	248	16,135	17,509	137	107	84	65
Granular	355	381	216	232	289	426	175	259	12,772	19,273	115	78	70	47
Chemical	67	42	42	26	60	45	38	28	3,374	W	10	2	6	1
Potassium sulfate	266	193	139	99	223	198	116	101	18,953	17,889	68	84	36	44
Other potassium salts[2]	425	378	[r]109	101	346	443	90	119	11,841	W	158	142	40	36
Total	2,416	2,243	1,298	1,218	1,935	2,437	1,038	1,314	93,872	111,419	877	957	472	522
July-December:														
Muriate of potash, 60% K_2O minimum														
Standard	[r]890	743	541	453	697	765	425	466	[r]32,712	26,010	580	522	353	316
Coarse	342	460	208	281	332	452	203	276	15,467	17,384	147	115	89	70
Granular	408	391	249	237	400	395	244	239	18,280	15,395	123	74	75	45
Chemical	42	44	27	28	46	45	29	28	2,780	W	5	1	3	1
Potassium sulfate	197	179	101	92	176	182	91	94	16,528	18,400	89	81	46	42
Other potassium salts[2]	282	356	77	91	233	324	64	83	8,218	W	207	174	53	45
Total	2,161	2,173	[r]1,203	1,182	1,884	2,163	1,056	1,186	93,985	91,217	1,151	967	619	519
Grand total	[r]4,577	4,416	2,501	2,400	3,819	4,600	2,094	2,500	187,857	202,636	XX	XX	XX	XX

[r]Revised. XX Not applicable. W Withheld to avoid disclosing individual company confidential data; included in "Total."
[1]F.o.b. mine.
[2]Includes soluble muriate, manure salts, and potassium magnesium sulfate.

Table 3.—Production and sales of potash in New Mexico

(Thousand short tons and thousand dollars)

Period	Potash ore[1]		Marketable potash				
			Production		Sold or used		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value[2]
1975:							
January-June	9,156	1,402	2,037	1,079	1,603	846	r73,988
July-December	8,653	1,298	1,817	1,002	1,618	903	76,634
Total	17,809	2,700	3,854	2,081	3,221	1,749	150,622
1976:							
January-June	8,583	1,289	1,876	1,005	2,069	1,098	92,744
July-December	8,725	1,271	1,834	984	1,820	985	72,610
Total	17,308	2,560	3,710	1,989	3,889	2,083	165,354

[1]Sylvinite and langbeinite.
[2]F.o.b. mine.

Table 4.—Salient statistics on sulfates of potash [1] [2]

(Thousand short tons of K_2O equivalent)

Item	1972	1973	1974	1975	1976
Production	325	376	394	386	381
Sales by producers	293	399	387	316	371
Exports	101	153	129	114	124
Imports	31	34	27	39	33
Apparent consumption	223	280	285	241	280
Yearend producers' stocks	81	40	29	90	81

[1]Potassium sulfate plus potassium magnesium sulfate; source: Potash Institute, Atlanta, Ga.
[2]Includes sulfate of potassium produced by conversion of purchased muriate of potassium.

International Minerals & Chemical Corp. leased acreage in northern Montana where supposed deposits of potash may have solution-mining potential.

Kaiser Chemicals announced construction by 1979 of an 8,000-acre, $3 million solar evaporation system to replace the old system at Wendover, Utah. The new system was scheduled to operate until 1995.

Mississippi Chemical Corp. began modernization and expansion of its flotation plant in New Mexico during late summer. The plant was closed approximately 4 months during the second half of 1976 and remained closed at yearend. Planned annual capacity of the renovated plant was approximately 180,000 tons of K_2O equivalent. The product, all muriate of potash, was to be used exclusively to manufacture fertilizer mixtures made in captive plants and marketed by Mississippi Chemical Corp.

National Potash Co. closed its Eddy County mine near Carlsbad in November when recovery of all available ore was completed. All future mining and milling was to be done at the Lea County mine site at a reduced annual capacity of near 240,000 tons of K_2O equivalent. Sylvinite ore from the Lea County mine, which had been opened in 1974, was leaner than that from the Eddy County mine.

The potash reserve in Potash Co. of America's New Mexico mine was increased by about one-half to 5.5 million tons of K_2O equivalent, all as muriate. The increase resulted largely from planned use of secondary mining techniques and newly defined ore body limits. The new reserve estimate allowed planned mining of this rich (25% K_2O) deposit to be extended into the late 1980's.

Texasgulf, Inc., determined that the remaining reserve in its Cane Creek mine in Utah is sufficient to allow potash recovery by solution mining for about 10 years at current rates of removal. Solution mining experimentation continued in new wells near Moab. A substantial resource of potash was indicated by the U.S. Geological Survey[2] in the Paradox Basin in Utah. The deposit occurs over a depth range of 5,000 to

[2]Hite, R. J. A Potential Target for Potash Solution Mining in Cycle 13, Paradox Member, Near Moab, Utah. U.S. Geol. Survey Open-File Rept. 76-755, 1976, 5 pp.

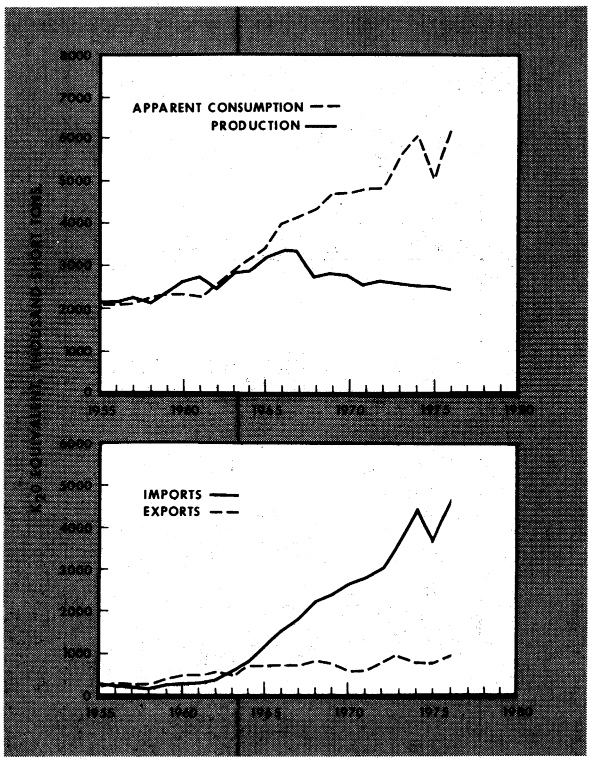

Figure 1.—Marketable production, apparent consumption, exports, and imports of potash measured in K_2O equivalent.

6,500 feet and has potential as a solution-mining target.

An indictment was filed on June 29 by the Antitrust Division of the U.S. Department of Justice in U.S. District Court, Northern District of Illinois, charging five U.S. producers with restricting trade by curbing U.S. production and stabilizing U.S. prices at noncompetitive levels and conspiring to coordinate U.S. and Canadian production and prices for potash; they were also indicted for coordinating exports of potash from the United States and imports of offshore potash into the United States. The case related to the prorationing system enforced by the Provincial government on the potash industry in Saskatchewan, Canada, from 1970 to 1974 and covered only that period of time. The criminal trial was scheduled to begin in January 1977. The potential fine was $50,000 per producer. The States of Illinois and Connecticut and some 30 other potash users filed class-action civil suits, mostly in the same Illinois court, seeking damages from the potash producers for the higher prices paid for potash during prorationing.

Leasing of Federal land near Carlsbad was renewed at mid-1976 after a 2-year moratorium caused by environmental considerations.

Exploratory drilling began on a southern extension of the Williston basin, in the Montana-North Dakota area near the Saskatchewan border, by two parties, Kalium Chemicals, a division of PPG Industries, Inc., and Farmers Potash Co., a combine of Burlington Northern, Inc. and C. F. Industries, Inc. Land leasing had begun in 1975. Five holes had been drilled by yearend at a cost of about $3 million in Burke and Bottineau Counties in North Dakota and in Daniels and Sheridan Counties in Montana. Preliminary data indicated that solution mining is technically feasible at depths of 7,000 to 9,000 feet. Engineering evaluations for commercial development were expected to be completed in 1977. Local lignite would be used for this energy-intensive operation. Immediate construction of pilot wells and mills was indicated, the main scheduling deterrent being local environmental considerations. Unit size for a commercial solution-mining operation would be about 1

Table 5.—Sales of North American potash, by State of destination

(Short tons of K_2O equivalent)

Destination	Agricultural potash		Nonagricultural potash		Destination	Agricultural potash		Nonagricultural potash	
	1975	1976	1975	1976		1975	1976	1975	1976
Alabama	76,677	108,470	43,490	44,227	Nebraska	44,218	58,695	165	322
Arizona	745	2,100	269	28	Nevada	--	117	184	540
Arkansas	31,421	53,398	869	255	New Hampshire	291	276	--	--
California	53,284	64,015	5,591	5,133	New Jersey	11,585	15,060	954	1,833
Colorado	8,510	14,362	1,223	529	New Mexico	7,159	2,372	281	468
Connecticut	2,666	3,806	134	229	New York	61,201	70,550	57,944	52,013
Delaware	19,669	27,617	23,460	24,004	North Carolina	122,181	153,593	730	1,489
Florida	189,166	191,196	786	598	North Dakota	16,118	16,652	14	41
Georgia	193,064	262,812	643	1,160	Ohio	330,428	401,923	33,841	39,450
Hawaii	20,933	26,309	--	--	Oklahoma	16,570	22,894	369	618
Idaho	11,466	15,946	--	--	Oregon	14,082	19,824	1,114	1,162
Illinois	609,721	818,259	38,612	41,903	Pennsylvania	55,732	74,006	3,275	4,049
Indiana	397,920	497,021	4,943	4,895	Rhode Island	1,829	2,447	251	523
Iowa	441,323	526,327	341	749	South Carolina	69,517	107,707	536	550
Kansas	30,245	52,280	1,367	1,822	South Dakota	10,815	10,527	--	--
Kentucky	93,907	133,198	15,196	16,550	Tennessee	83,623	130,908	90	546
Louisiana	40,033	50,298	439	779	Texas	196,399	213,248	14,704	16,113
Maine	9,891	15,262	106	156	Utah	1,968	772	137	154
Maryland	45,353	63,776	1,528	1,739	Vermont	5,396	6,668	--	--
Massachusetts	1,909	2,925	636	809	Virginia	75,878	76,041	1,037	1,307
Michigan	146,994	191,906	1,779	2,513	Washington	29,005	36,003	2,927	3,436
Minnesota	355,293	405,016	801	70	West Virginia	2,230	4,813	131	50
Mississippi	175,743	191,105	3,020	2,256	Wisconsin	262,737	336,114	223	195
Missouri	179,112	238,555	2,197	3,142	Wyoming	1,462	1,780	1,275	1,008
Montana	3,909	9,082	472	666					
					Total	4,559,378	5,728,031	268,084	280,079

Source: Potash Institute, Atlanta, Ga.

Table 6.—Sales of North American potash to U.S. customers, by type and grade

(Short tons of K_2O equivalent)

	1975	1976
Agricultural:		
Muriate of potash:		
Standard	1,065,094	1,174,355
Coarse	1,810,745	2,270,698
Granular	1,186,748	1,642,338
Soluble	298,325	396,980
Sulfate of potash	113,896	128,336
Potassium magnesium sulfate	84,570	115,324
Total	4,559,378	5,728,031
Nonagricultural:		
Muriate	197,284	186,604
Soluble muriate	67,522	89,917
Sulfate of potash	3,278	3,558
Total	268,084	280,079
Grand total	4,827,462	6,008,110

Source: Potash Institute, Atlanta, Ga.

million tons of K_2O equivalent at a capital cost of about $300 million. Estimated resources were sufficient to satisfy U.S. demand for centuries.

Exploratory drilling was completed for evaluating potash resources in a 29.6-square-mile area 35 miles east of Carlsbad, N. Mex. This area had been selected by the U.S. Energy Research and Development Administration (ERDA) as the prime candidate for its nuclear Waste Isolation Pilot Plant (WIPP) project. Storage would be realized by about 1983 in a 2,000-foot-thick halite bed at a depth of about one-half mile if the area was determined to be geologically, ecologically, and economically suitable. Two potash-mining leases would be affected. In late 1976, the Federal Bureau of Mines began an engineering-economic study to determine the potential potash reserves that would be removed by construction of WIPP. The Bureau's reserve estimate, based on 21 exploratory holes drilled for ERDA and on previous drillings, was expected during 1977.

CONSUMPTION AND USES

Apparent domestic consumption of potash increased 20% to 6.15 million tons of K_2O equivalent; approximately 95% of this was used in the fertilizer industry and the balance in chemicals manufacture, mainly in production of caustic potash. Consumption was stimulated by price reductions during the summer.

The north-central States of Illinois, Indiana, Iowa, Ohio, Minnesota, and Wisconsin purchased 52% of all agricultural potash, compared with 53% in 1975.

Total sales in the United States of muriate of potash for agricultural purposes follow: Standard grade, up 10% to 1.17 million tons K_2O, coarse grade, up 25% to 2.27 million tons K_2O, granular grade, up 38% to 1.64 million tons K_2O; and soluble grade, up 33% to 0.40 million tons K_2O, according to the Potash Institute.

Apparent consumption of potassium sulfate and potassium magnesium sulfate combined increased 16% to 0.28 million tons of K_2O, according to the Potash Institute. However, 1975 apparent consumption had dropped 15% compared with that of 1974.

STOCKS

Domestic producers' inventories decreased during 1976 by 0.10 million tons to 0.52 million tons of K_2O equivalent; most of this decrease occurred during the first half of the year. These stockpiles had increased in 1975 by 0.41 million tons. Producers' inventories of sulfates of potash decreased 10% in 1976 to 0.08 million tons of K_2O.

PRICES

Domestic prices for muriate of potash decreased significantly below the 1975 highs, particularly during the latter half of 1976, when the average price for the three common grades of muriate dropped to $59.93 per ton of K_2O equivalent, or 21% below the 1975 average. The price of standard muriate was particularly depressed because of lack of demand in the domestic market. Sulfate of potash prices continued to climb significantly.

Table 7.—Bulk prices of U.S. potash, by type and grade [1]

(U.S. cents per unit K_2O)

	1973	1974	1975		1976	
			January-June	July-December	January-June	July-December
Muriate, 60% K_2O minimum:						
Standard	34.60	52.65	76.23	76.97	69.21	55.82
Coarse	37.92	53.37	75.05	76.19	70.60	62.99
Granular	38.81	51.27	72.98	74.92	74.41	64.41
All muriate [2]	36.39	52.50	75.19	76.56	70.80	59.93
Sulfate, 50% K_2O minimum	82.68	110.79	163.39	181.63	[3]177.00	[3]224.02

[1]Average prices based on actual sales, f.o.b. mine.
[2]Excluding soluble and chemical muriates.
[3]Average price includes price of sulfate produced by conversion of purchased muriate.

FOREIGN TRADE

Total U.S. exports[3] of potash increased 21% to 0.95 million tons of K_2O equivalent. Areas receiving these exports were Latin America, 55%, Oceania, 21%, Asia, 17%, and other, mainly Western Europe, 7%. Exports of sulfates of potash increased 9% to 0.12 million tons of K_2O. Exports of potash to Brazil, the main recipient country, increased 34% to 0.38 million tons of K_2O. New Zealand became the second largest importer of U.S. potash; exports to that country approximately doubled to 0.16 million tons of K_2O. Japan remained the largest importer of U.S. sulfates of potash.

Potash imports, 97% from Canada, increased 21% to 4.59 million tons of K_2O equivalent. Muriate of potash comprised 99% of these imports. Israel remained the second-place supplier, providing nearly 2% of U.S. imports in 1976. Imports from centrally controlled economy countries more than doubled but remained below 0.03 million tons of K_2O.

[3]Salient U.S. trade data includes only muriate, sulfate, nitrate, and potassium magnesium sulfate.

Table 8.—U.S. exports of potash materials, by use

Materials	Approximate equivalent as potash (K_2O) percent	1975 Quantity (short tons)	1975 Approximate equivalent as potash (K_2O) Short tons	1975 Approximate equivalent as potash (K_2O) Percent of total	1975 Value[1] (thousands)	1976 Quantity (short tons)	1976 Approximate equivalent as potash (K_2O) Short tons	1976 Approximate equivalent as potash (K_2O) Percent of total	1976 Value[1] (thousands)
Used chiefly as fertilizers:									
Potassium chloride all grades	r61	1,020,166	r622,301	r76.3	$64,904	1,329,399	810,933	83.7	$68,763
Potassic chemical fertilizer, n.e.c	40	384,152	153,661	r18.8	26,837	329,706	131,882	13.6	22,977
Natural potassic salt fertilizer, crude	20	14,999	3,000	.4	[2]960	10,586	2,117	.2	147
Total	XX	1,419,317	r778,962	r95.5	[2]92,701	1,669,691	944,932	97.5	91,887
Used chiefly in chemical industries:									
Potassium hydroxide	80	9,236	7,389	.9	2,095	11,057	8,845	.9	2,811
Potassium peroxide	83	3	2	([3])	1	--	--	--	--
Potassium compounds, n.e.c	31	95,258	29,530	r3.6	16,853	48,968	15,180	1.6	16,611
Total	XX	104,497	36,921	r4.5	18,949	60,025	24,025	2.5	19,422
Grand total	XX	1,523,814	r815,883	100.0	[2]111,650	1,729,716	968,957	100.0	111,309

rRevised. XX Not applicable.
[1]F.a.s., U.S. port.
[2]Adjusted by the Bureau of Mines.
[3]Less than 1/2 unit.

Table 9.—U.S. exports of potash materials, by country

Destination	Fertilizer: Chloride Quantity (short tons)		Fertilizer: Chemical fertilizer n.e.c. Quantity (short tons)		Fertilizer: Total Quantity (short tons)		Fertilizer: Total Value[1] (thousands)		Chemical: Hydroxide (caustic) Quantity (short tons)		Chemical: Other n.e.c. Quantity (short tons)		Chemical: Total Quantity (short tons)		Chemical: Total Value[1] (thousands)	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Argentina	1,653	2,037	1,802	4,488	3,455	6,525	$389	$404	--	--	182	392	182	392	$136	$314
Australia	73,514	45,906	1,608	13,561	75,122	[2]61,141	3,731	[2]4,229	--	24	3,547	148	3,547	172	571	192
Belgium-Luxembourg	--	4,998	--	--	--	4,998	--	247	--	--	11,279	5,442	11,279	5,442	796	513
Brazil	343,715	596,636	130,925	50,497	474,640	[2]654,962	29,672	[2]33,357	286	2,720	46,249	8,828	46,535	11,548	3,944	2,374
Canada	5,618	5,605	55,349	63,145	[2]71,493	[2]69,326	[2]3,938	[2]4,166	7,363	6,086	7,953	7,485	15,316	13,571	5,079	4,606
Chile	--	886	--	1,156	--	2,042	--	112	--	11	54	78	54	89	55	56
China, People's Republic of	--	--	--	--	--	--	--	--	--	--	434	--	434	--	222	--
Colombia	7,385	4,409	15,168	3,347	[2]26,929	7,756	[2]2,233	553	87	165	4,974	200	5,061	365	335	167
Costa Rica	23,820	19,091	6,502	8,321	30,322	27,412	2,538	1,496	1	--	22	33	23	33	10	14
Dominican Republic	11,778	32,539	1,260	--	13,038	32,539	1,290	2,070	1	18	42	96	43	114	32	67
Ecuador	--	--	--	--	--	--	--	--	--	--	5	23	5	23	9	17
El Salvador	5,511	--	7,850	--	13,361	--	1,046	--	--	--	4	--	4	--	7	--
Finland	--	--	44	--	44	--	2	--	--	--	5	--	5	--	3	--
France	--	--	--	--	--	--	--	--	--	11	27	24	27	35	101	30
Germany, West	5,724	--	--	--	5,724	--	338	--	--	20	4,667	3,764	4,667	3,784	2,832	2,094
Guatemala	--	--	--	308	--	308	--	11	17	5	5	65	22	70	13	34
Guyana	1,302	565	277	479	1,579	1,044	211	125	--	--	5	2	5	2	3	6
Honduras	451	1,176	45	196	496	[2]1,417	66	[2]140	--	--	10	4	10	4	15	9
India	--	--	--	--	--	--	--	--	--	326	53	63	53	389	14	169
Indonesia	--	--	--	--	--	--	--	--	1	--	95	280	96	280	58	107
Ireland	10,098	7,306	--	--	10,098	7,306	509	354	--	--	1	--	1	--	2	--
Israel	--	17	--	--	--	17	--	1	316	--	17	1	333	1	102	4
Italy	79	--	--	--	[2]119	[2]24	[2]4	[2]1	--	--	118	21	118	21	84	14
Jamaica	14,050	6,500	--	--	14,050	6,500	1,126	504	11	7	27	5	38	12	36	15
Japan	92,176	97,042	79,930	96,345	172,106	193,387	11,397	12,113	--	46	178	212	178	258	504	3,227
Korea, Republic of	3,300	--	29,070	27,832	32,370	27,832	2,772	2,299	--	6	54	316	54	322	32	148
Malaysia	15,899	17,495	--	5,518	15,899	23,013	1,659	869	--	--	15	16,804	15	16,804	15	1,212
Mexico	135,936	154,903	23,550	37,455	[2]159,524	[2]192,508	[2]9,442	[2]10,021	239	1,149	1,458	2,010	[4]1,699	3,159	[4]830	1,316
Netherlands	--	39	--	--	--	[2]72	--	[2]2	60	82	172	185	232	267	160	223
Netherlands Antilles	--	--	--	--	--	--	--	--	269	48	--	(3)	269	48	118	16
New Zealand	121,397	241,907	--	--	121,397	241,907	8,366	12,574	19	6	32	59	51	65	30	62
Nicaragua	728	2,040	41	1,157	769	3,197	116	261	--	--	4	22	4	22	10	33
Panama	2,600	--	54	31	2,654	31	340	5	--	--	33	69	33	69	24	54
Peru	59	51	--	9,920	59	9,971	4	834	9	6	154	125	163	131	184	120
Philippines	33,073	28,028	1,515	--	34,588	28,028	1,961	1,506	3	7	67	101	70	108	52	116

Singapore	268	--	7,898	5,180	8,166	5,180	474	479	1	--	26	38	27	38	46	160
South Africa, Republic of	54	4,503	--	--	54	4,503	2	231	--	38	5,845	112	5,845	150	545	141
Spain	3,638	--	--	--	3,638	[2]35	147	[2]1	--	115	13	13	13	128	8	53
Sweden	594	20,338	--	--	[2]611	20,338	[2]71	1,070	--	--	59	11	59	11	51	10
Taiwan	98,575	3,942	--	--	98,575	3,942	7,138	183	--	--	23	236	23	236	16	134
Thailand	5,511	--	15,321	--	20,832	--	1,286	--	--	--	([3])	3	([3])	3	1	4
U.S.S.R.	--	--	--	--	--	--	--	--	--	--	1	331	1	331	3	156
United Kingdom	44	19,982	--	--	44	[2]20,186	1	[2]926	42	--	6,657	244	6,699	224	748	220
Uruguay	--	--	5,407	386	5,407	386	297	25	--	--	89	30	89	30	69	16
Venezuela	406	26	--	25	406	51	13	8	341	29	404	387	745	416	457	218
Vietnam	927	--	--	--	927	--	45	--	--	--	17	--	17	--	5	--
Other	283	11,432	536	359	[2]821	[2]11,807	[2 5]77	[2]710	170	132	182	726	[4]353	858	[4]582	981
Total	1,020,166	1,329,399	384,152	329,706	[2]1,419,317	[2]1,669,691	[2 5]92,701	[2]91,886	9,236	11,057	95,258	48,968	[4]104,497	60,025	[4]18,949	19,422

[1]F.a.s., U.S. port.

[2]Includes crude natural potassic salt fertilizer—1975: Canada, 10,526 tons ($588,378); Colombia, 4,376 tons ($366,521); Italy, 40 tons ($1,340); Mexico, 38 tons ($1,275); Sweden, 17 tons ($564); Switzerland, 2 tons ($2,400). 1976: Australia, 1,674 tons ($93,940); Brazil, 7,829 tons ($6,526); Canada, 576 tons ($22,376); Honduras, 45 tons ($6,623); Hong Kong, 16 tons ($540); Italy, 24 tons ($1,183); Mexico, 150 tons ($7,105); Netherlands, 33 tons ($1,106); Spain, 35 tons ($1,167); the United Kingdom, 204 tons ($6,846).

[3]Less than 1/2 unit.

[4]Includes potassium peroxide—1975: Bermuda, 1 ton ($1,284); Mexico, 24 tons ($700). 1976: No exports of potassium peroxide.

[5]Adjusted by the Bureau of Mines.

Table 10.—U.S. imports for consumption of potash materials, by use

Materials	Approximate equivalent as potash (K_2O) percent	1975 Quantity (short tons)	1975 Approximate equivalent as potash (K_2O): Short tons	1975 Approximate equivalent as potash (K_2O): Percent of total	1975 Value (thousands): Customs	1975 Value (thousands): C.i.f.	1976 Quantity (short tons)	1976 Approximate equivalent as potash (K_2O): Short tons	1976 Approximate equivalent as potash (K_2O): Percent of total	1976 Value (thousands): Customs	1976 Value (thousands): C.i.f.
Used chiefly as fertilizers:											
Muriate (chloride)	r61	6,131,931	r3,740,478	98.2	$248,392	$314,242	7,474,534	4,559,465	99.1	$332,301	$422,396
Potassium nitrate, crude	40	35,791	14,316	.4	7,016	7,755	13,623	5,449	.1	2,297	2,695
Potassium sodium nitrate mixtures, crude	14	24,947	3,493	.1	4,388	4,963	40,020	5,603	.1	5,345	5,517
Potassium sulfate, crude	50	76,968	38,484	1.0	7,393	8,086	46,848	23,424	.5	4,106	4,507
Other potash fertilizer material	6	1,839	110	(1)	122	137	3,301	198	(1)	180	186
Total	XX	6,271,476	r3,796,881	99.7	267,248	335,183	7,578,326	4,594,139	99.8	344,229	435,301
Used chiefly in chemical industries:											
Bicarbonate	46	1,671	769		464	584	916	421		241	314
Bitartrate: Cream of tartar	25	503	126		751	802	728	182		646	714
Carbonate	61	2,239	1,366		598	728	2,281	1,391		590	732
Caustic	80	7,171	5,737		2,721	3,388	721	578		288	358
Chlorate and perchlorate	36	224	81		93	117	1,271	458		434	589
Cyanide	70	297	208	.3	244	274	1,151	806	.2	1,069	1,188
Ferricyanide	42	444	186		625	670	504	212		755	804
Ferrocyanide	44	769	338		679	725	766	337		706	753
Nitrate	50	765	383		197	228	129	64		38	42
Rochelle salts	22	190	42		254	273	357	79		312	345
Sorbate	26	1,618	421		4,626	4,965	2,422	630		6,621	7,211
All other	31	4,962	1,538		6,772	7,246	5,674	1,759		4,827	5,373
Total	XX	20,853	11,195	.3	18,024	20,000	16,920	6,917	.2	16,527	18,423
Grand total	XX	6,292,329	r3,808,076	100.0	285,272	355,183	7,595,246	4,601,056	100.0	360,756	453,724

[r]Revised. XX Not applicable.
[1]Less than 1/2 unit.

Table 11.—U.S. imports for consumption of potash materials, by country

(Short tons)

Year and country	Bitartrate cream of tartar	Caustic (hydroxide)	Chlorate and perchlorate	Cyanide	Muriate (chloride)	Potassium nitrate, crude	Potassium sodium nitrate mixtures, crude	Potassium nitrate (saltpeter), refined	Potassium sulfate	All others	Total: Quantity	Total: Value (thousands): Customs	Total: Value (thousands): C.i.f.
1975:													
Argentina	20	--	--	--	--	--	--	--	--	--	20	$27	$29
Belgium-Luxembourg	--	221	--	--	--	--	--	--	8,267	108	8,596	1,030	1,117
Canada	--	64	--	--	5,954,187	2	2,045	20	196	2,264	5,958,778	239,357	303,301
Chile	--	--	--	--	3,360	--	2,828	--	--	--	6,188	749	884
Congo	--	--	--	--	61,007	--	--	--	--	--	61,007	3,679	4,190
France	--	1,342	--	--	--	--	--	--	22,801	1,146	25,289	3,143	3,495
Gaza Strip	--	--	--	--	3,673	--	--	--	--	--	3,673	62	83
Germany, West	--	819	--	149	11,039	--	--	85	45,704	5,357	63,153	10,033	11,055
Israel	--	--	--	--	81,580	35,787	14,877	600	--	130	132,974	15,243	17,607
Italy	201	--	--	--	--	--	--	--	--	23	224	300	292
Japan	--	4,366	--	17	--	--	--	--	--	2,099	6,482	7,888	8,204
Netherlands	--	79	--	--	--	--	--	--	--	516	595	290	334
Norway	--	--	--	--	--	--	5,197	--	--	--	5,197	796	878
Spain	280	--	22	--	--	--	--	--	--	153	455	671	714
Sweden	--	280	201	--	--	--	--	--	--	62	543	259	303
Switzerland	--	--	1	--	--	--	--	--	--	40	41	107	112
U.S.S.R.	--	--	--	--	16,151	--	--	--	--	--	16,151	1,123	1,292
United Kingdom	--	(1)	--	131	326	2	--	--	--	679	1,138	729	822
Other	2	--	--	--	608	--	--	60	--	1,155	1,825	286	471
Total	503	7,171	224	297	6,131,931	35,791	24,947	765	76,968	13,732	6,292,329	285,272	355,183
1976:													
Belgium-Luxembourg	--	13	--	--	--	--	--	--	13,007	424	13,444	1,262	1,401
Canada	--	(1)	--	(1)	7,279,590	300	331	39	1,190	3,493	7,284,943	324,001	412,018
Chile	--	--	--	--	6,344	--	27,420	--	--	--	33,764	3,728	3,750
China, People's Republic of	--	--	--	--	--	--	--	--	--	34	34	18	23
Congo	--	--	--	--	17,361	--	--	--	--	--	17,361	820	976
France	--	20	--	--	--	--	--	--	16,000	838	16,858	1,883	1,963
Germany, East	--	--	--	--	44,345	--	--	--	--	94	44,439	2,188	2,705
Germany, West	--	492	--	477	10,025	2	--	40	16,651	5,082	32,769	5,793	7,026
Israel	--	--	--	--	94,492	13,319	12,269	--	--	83	120,163	8,952	10,207
Italy	465	--	--	63	--	--	--	--	--	119	647	632	698
Japan	--	14	--	176	--	2	--	--	--	2,858	3,050	7,820	8,522
Netherlands	--	--	--	--	--	--	--	--	--	656	656	314	374

See footnotes at end of table.

Table 11.—U.S. imports for consumption of potash materials, by country —Continued

(Short tons)

Year and country	Bitartrate cream of tartar	Caustic (hydroxide)	Chlorate and perchlorate	Cyanide	Muriate (chloride)	Potassium nitrate, crude	Potassium sodium nitrate mixtures, crude	Potassium nitrate (saltpeter), refined	Potassium sulfate	All others	Total: Quantity	Total: Value (thousands): Customs	Total: Value (thousands): C.i.f.
1976: —Continued													
Spain	263	--	948	--	22,376	--	--	--	--	247	23,834	1,589	1,988
Sweden	--	182	315	--	--	--	--	--	--	80	577	263	323
Switzerland	--	--	8	--	--	--	--	--	--	13	21	72	78
U.S.S.R.	--	--	--	--	--	--	--	--	--	3	3	6	7
United Kingdom	--	--	--	435	1	--	--	--	--	870	1,306	1,219	1,388
Other	--	--	--	--	--	--	--	49	--	1,328	1,377	196	277
Total	728	721	1,271	1,151	7,474,534	13,623	40,020	128	46,848	16,222	7,595,246	360,756	453,724

[1]Less than 1/2 unit.

WORLD REVIEW

Potash production in 1976 continued to rise in Eastern Europe, although at a slower rate than in previous years, and continued to decrease in the Western World. Eastern European production increased 5% to 12.6 million tons of K_2O equivalent; production in Western Europe, including Israel and the People's Republic of the Congo,[4] and North America decreased 8% and 7% to 5.8 and 7.9 million tons of K_2O, respectively.

The apportionment of world production was Eastern Europe, 47%, North America, 29%, Western Europe, including Israel and the People's Republic of the Congo, 22%, and others, mainly the People's Republic of China, 2%. The U.S.S.R. and Canada continued as the first and second largest producers, with 34% and 21% of the world's 1976 output, respectively.

The only significant capacity increases during 1976 were in Eastern Europe, particularly in the U.S.S.R. where export markets including Western markets were sought.

The only significant expansion that occurred in Western Europe in the 1970's was the construction of the Boulby mine in the United Kingdom which was expected to produce at about one-half capacity in 1977; reported capacity was 0.55 million short tons of K_2O per year.

Each of the three major potash-producing world blocs, North America, Western Europe, and Eastern Europe, remained self-sufficient in potash. North American net export decreased 3% in 1976 to 1.76 million tons of K_2O. Net export from Eastern Europe increased 2% to 1.71 million tons. West European net imports increased 4% to 0.13 million tons in 1976. Approximately 60% of world consumption was in producing countries. Total world demand increased about 10% to approximately 26 million tons of K_2O indicating a cessation of the previous rapid buildup of producers' inventories.

An anticipated increase in Western European consumption in 1976 was not realized, partly because of a drought; consequently, producers' inventories remained high.

Combined exports in 1976 of the two Eastern European producers, the U.S.S.R. and East Germany, remained at about 5.1 million tons, equaling about 40% of 1976 production. Areas receiving these exports were other Eastern European countries, 66%; Western Europe, 20%; Asia, 8%; and Latin America, 6%. Eastern European exports to Latin America increased 85% to 0.33 million tons.

Total exports from Western European primary-producing countries, which included, in order of production volume, West Germany, France, Israel, Spain, the People's Republic of the Congo, and Italy, decreased 3% to 2.08 million tons of K_2O. Areas receiving these exports were Western Europe, 58%; Asia, 15%; Africa, 13%; Latin America, 9%; North America, 5%; and Eastern Europe, 2%.

A new trade organization, Austria, Kali-Export GmbH based in Vienna, was formed to administer export trade by West Germany, France and the People's Republic of the Congo, Israel, and the United Kingdom.

Total overseas exports from North America decreased 10% to 1.90 million tons. Areas receiving these exports were Asia, mainly Japan, 46%; Latin America, mainly Brazil, 36%; Oceania, 13%; Western Europe, 4%; and others, 1%.

Total world shipments to nonproducing nations decreased 2% to 8.54 million tons; receiving areas were, in order of volume, Eastern Europe, mainly Poland and Hungary, 39%; Western Europe, mainly Belgium and the United Kingdom, 21%; Asia, mainly Japan and India, 19%; Latin America, mainly Brazil, 14%; Africa, mainly the Republic of South Africa, 4%; and Oceania, 3%. Major suppliers were East Germany and the U.S.S.R. to Eastern Europe; Canada, East Germany, the U.S.S.R., West Germany, the United States, and Israel, in order of volume, to Asia; and the United States, East Germany, Canada, the U.S.S.R. and West Germany, in order of volume, to Latin America. Imports into Brazil, the market-economy world's largest nonproducing importer, increased 46% to 0.83 million tons. Imports into Japan, the second

[4]Israel and the People's Republic of the Congo are included in Western Europe because they were in the same trading block.

largest nonproducing importer in the market-economy world, decreased 29% in 1976 to 0.70 million tons of K_2O. Large user inventories were reported in Asia.

Total 1976 exports of potassium sulfates from Western European producing countries increased 4% to 0.56 million tons of K_2O. Of this, 50% was shipped to nonproducing Western European countries. East Germany, the only other sulfates exporter except for the United States, increased sulfate exports by about 50% to approximately 0.10 million tons of K_2O. Of this, about 80% was shipped to Eastern European countries.

Brazil.—A consortium of government and private concerns was formed to undertake a feasibility study and build a pilot plant to exploit the carnallite and sylvinite deposits in the Sergipe Basin. Reserves and resources of potash in Brazil were estimated to be 60 million and 300 million tons of K_2O equivalent, respectively.

Brazilian consumption of potash increased 40% in 1976 to 0.78 million short tons of K_2O, all of which was imported.

Canada.—Production remained at little more than 50% of capacity during the first 6 months because of lagging U.S. demand at the farm level, lower overseas sales, and high producers' inventories.[5] Substantial price cuts during the summer increased sales greatly in the second half of the year. However, total 1976 production decreased 8% to 5.51 million tons. Producers' inventories decreased by only 0.21 million tons to 0.88 million tons of K_2O equivalent; of this, 49% was standard grade muriate or finer. Overseas exports decreased 27% to 0.99 million tons reflecting both decreased demand and increased competition abroad. Areas receiving these exports during 1976 were Asia, 73%; Latin America, 17%; and others, mainly Oceania, 10%.

Exports to the United States increased 27% to 4.44 million tons of K_2O. Domestic consumption in Canada increased by about 9% to approximately 0.27 million tons of K_2O. Imports, mostly sulfates of potash from the United States, remained at about 19,000 tons of K_2O.

International Minerals & Chemical Corp. (Canada). closed their K-2 mine at Esterhazy in January for an indefinite period; however, it was reopened in September because of the improved market. A new heavy-media circuit was put onstream in September. Effective total annual capacity at Esterhazy was increased 16% to about 2.7 million tons of K_2O by yearend.

Sylvite of Canada, Ltd. purchased a third Marietta continuous miner in 1976. Alwinsal Potash of Canada, Ltd., ordered a new continuous miner; the firm's facility was shut down for part of 1976 because of major storm damage. Several facilities added more compaction presses for conversion of standard-grade muriate into coarser fertilizer–blending grades. Many producers stated that further capacity expansions were inhibited by the high level of Provincial taxation, which, combined with Federal taxes, prevented realization of a reasonable return on their investment. Provincial taxes alone averaged about $20 per ton of K_2O for Saskatchewan fiscal year 1976.

The government of the Province of Saskatchewan began acquisition of the Province's potash industry by the purchase in October of Duval Corp. of Canada's mine and mill near Saskatchewan. Legislation enabling expropriation had been passed by the Saskatchewan government in January, although the government reportedly planned to acquire the properties by negotiation. Near yearend the government announced plans to expand its newly acquired facility, renamed Cory Limited, by 25% to an annual capacity of about 0.9 million tons of K_2O; this included procurement of a new continuous miner. The Potash Corp. of Saskat-

[5]Data on Canadian production, inventory, and overseas exports were supplied by the Potash Institute, Atlanta, Ga.

Table 12.—Salient statistics on Canadian potash

(Short tons of K_2O equivalent)

	1975	1976
Production	5,991,840	5,506,996
Sales to North American customers	3,758,986	4,715,840
Exports		
United States	3,507,920	4,441,541
Overseas	1,353,742	986,580
Inventory at yearend	1,090,963	880,754
Domestic consumption	251,066	274,299

Source: Potash Institute, Atlanta, Ga.

chewan, the government-owned operator of government-acquired mines, completed appraisal of two more mines, owned by Sylvite of Canada, Ltd., and Alwinsal Potash of Canada, Ltd., respectively, and negotiations for acquisition of the Sylvite facility were progressing by yearend. Government appraisal of Central Canada Potash Ltd.'s mine was begun, and plans for appraisal of the Allan mine owned by A.P.M. Operators Ltd. were announced at yearend. A Saskatchewan government representative announced that acquisition of 50% or more of the Saskatchewan potash industry would be completed by 1979. The main sales office of the Potash Corp. of Saskatchewan was established in Atlanta, Ga., and the government-owned firm became a member of the Potash Institute.

Kalium Chemicals Ltd., Amax Chemical Corp., and Potash Co. of America Ltd. withdrew their membership from Canpotex Ltd., the Canadian export association. The Potash Corp. of Saskatchewan joined Canpotex.

Nine potash producers filed, in May 1976, an action in the Court of Queen's Bench in Regina, alleging breach of contract by the Saskatchewan government in connection with the reserve tax and prorationing fees. Under an agreement signed in 1960, the government had agreed not to increase royalties or royalty-like charges for a period of 21 years. Both this suit and those filed by industry in 1975, maintaining that the reserves tax and the prorationing fee are unconstitutional, were pending at yearend. Industry claimed that the heavy tax structure was excessive and prohibited expansion. The Provincial government refused to modify the tax structure and continued to recommend expansion. The Canadian Potash Producers' Association pledged to continue to seek tax reform.

The Supreme Court of Canada ruled on October 5, 1976, that, in the event the reserves tax and the prorationing fee were declared *ultra vires*, producers could recover all back reserve taxes paid to the Saskatchewan government. That government had legislated that retroactive taxes did not have to be returned to the producers; subsequently, 11 potash producers had filed suit alleging that enactment of this legislation exceeded the power of the Province. As a result of the Supreme Court decision, most of the reserve taxes that had been withheld by the producers were relinquished to the government.

The Saskatchewan Court of Queen's Bench had ruled in May 1975 that the prorationing legislation enacted by the Saskatchewan government in 1969 was unconstitutional. The suit had been filed by Central Canada Potash Ltd., later joined by the Attorney General of Canada. After this ruling, most producers withheld payment of the prorationing fee, $1.20 per ton. However, the Saskatchewan Court of Appeal overturned this ruling on January 11, 1977, declaring that the prorationing legislation was constitutional. Central Canada Potash Ltd. then filed an appeal on January 20, 1977, with the Supreme Court of Canada.

Promising potash exploration continued in New Brunswick, Canada. Drilling by International Minerals & Chemical Corp. outlined a rich sylvinite deposit averaging 29% K_2O in a 70-foot-thick bed within a 2-square-mile area near Salt Springs in Kings County. Ten holes were drilled in 1976. On the basis of seven holes that intersected the deposit, bed thickness and grade were found to be variable. The bed was located on one side of an anticline, and faulting was indicated. Bed depth ranged from 2,000 to 3,400 feet. The bed was underlain with a thick deposit of 98% halite. The intent was to combine halite and potash mining at the same location. Exploratory drilling was expected to continue throughout most of 1977. The company had been licensed by the Province of New Brunswick to explore a 77-square-mile area.

The Potash Co. of America continued exploration of a sylvinite potash deposit near Sussex, Kings County, New Brunswick. Exploratory drilling was terminated in August; nearly 30 exploratory holes had been drilled over a 3-year period. This deposit was found to be folded and to contain, reportedly, some carnallite. The company notified the New Brunswick government in October that they would submit a plan for commercial development within 1 year.

The Province of New Brunswick passed legislation in late 1976 fixing the royalty on mineral products at 6.5% of the average world market price for the first 15 years of plant production.

It appeared that commercial development of the New Brunswick deposits is technically feasible although overall production costs would likely be higher than in Saskatchewan. An indicated advantage was that the New Brunswick deposits are near an Atlantic port.

Table 13.—World

(Thousand short tons

Importing areas	Source: Canada 1975	Canada 1976	France[2] 1975	France[2] 1976	Germany, West 1975	Germany, West 1976	Germany, East 1975	Germany, East 1976	Israel 1975	Israel 1976
Africa:										
South Africa, Republic of	10	20	80	65	63	48	--	--	--	24
Other	--	--	52	56	5	4	12	3	--	11
Total Africa	10	20	132	121	68	52	12	3	--	35
Asia:										
China	90	--	--	--	--	--	16	21	--	--
India	82	93	--	--	20	97	122	135	--	--
Japan	429	315	9	31	125	52	29	23	100	34
Korea, South	298	103	--	--	--	--	--	--	--	--
Malaysia	52	50	18	--	1	--	--	--	--	44
Philippines	26	27	--	--	2	1	--	--	--	1
Taiwan	37	100	--	--	11	--	--	--	--	--
Other	24	28	14	22	24	21	31	44	1	--
Total Asia	1,038	716	41	53	183	171	198	223	101	79
Latin America:										
Brazil	126	142	22	31	57	67	67	137	--	19
Cuba	3	--	--	--	17	7	56	68	--	--
Mexico	--	--	--	--	--	--	--	--	--	--
Other	44	21	2	2	23	12	--	16	--	2
Total Latin America	173	163	24	33	97	86	123	221	--	21
North America:										
Canada	XX	XX	--	--	--	--	--	--	--	--
United States	3,508	4,442	29	--	30	22	17	--	82	53
Total North America	3,508	4,442	29	--	30	22	17	--	82	53
Oceania:										
Australia	62	59	--	--	2	1	--	--	--	--
New Zealand	31	--	--	--	1	2	--	--	--	--
Total Oceania	93	59	--	--	3	3	--	--	--	--
Western Europe:										
Austria	--	--	9	5	22	45	80	66	--	--
Belgium	--	--	56	60	108	46	44	7	--	11
France	--	--	XX	XX	8	13	11	25	85	--
Ireland	--	--	34	38	19	46	28	47	1	18
Italy	11	21	43	62	6	6	34	38	85	70
Netherlands	--	--	26	29	27	42	29	35	18	20
Scandinavia	--	--	56	5	208	199	128	93	22	24
United Kingdom	6	8	49	38	119	83	113	169	--	46
Other	23	--	97	75	12	14	42	79	10	--
Total Western Europe	40	29	370	312	529	494	509	559	221	189
Eastern Europe:										
Czechoslovakia	--	--	--	--	13	--	543	532	--	--
Hungary	--	--	2	--	19	8	[7]195	295	--	--
Poland	--	--	--	--	8	14	612	506	--	--
Yugoslavia	--	--	--	--	6	6	106	123	--	--
Other	--	--	2	5	19	3	69	74	--	--
Total Eastern Europe	--	--	4	5	65	31	1,525	1,530	--	--
World total	4,862	5,429	600	524	975	859	2,384	2,536	404	377

XX Not applicable.

[1]Data on U.S. and Canadian exports supplied by the Potash Institute; data on exports from other countries supplied by the International Phosphate Industry Association (ISMA, Ltd.), Paris, France.

[2]Includes Congolese exports.

[3]Excludes Belgian exports to avoid double counting.

[4]Source country breakdown incomplete for 1975.

[5]Includes imports from the United States only.

[6]Scandinavian imports from France, West Germany, and Israel taken from Phosphorus and Potassium, No. 85, October/November 1976, published by the British Sulphur Corp., Ltd.

[7]Hungarian imports from East Germany taken from Phosphorus and Potassium, No. 87, January/February 1977.

trade in potash[1]

of K_2O equivalent)

countries													
Italy		Spain		United States		U.S.S.R.		Belgium		Total [3]			
1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1973	1974	1975	1976
--	--	--	13	3	3	--	--	16	4	186	201	[4]202	173
31	29	30	27	--	--	--	--	10	16	94	140	130	130
31	29	30	40	3	3	--	--	26	20	280	341	[4]332	303
--	--	--	--	--	--	--	--	--	--	39	160	106	21
--	--	--	--	--	--	7	3	--	--	431	463	231	328
--	--	8	2	95	106	191	133	23	27	822	948	986	696
12	3	--	--	12	15	--	--	--	--	149	206	322	121
--	--	--	--	12	19	--	--	--	--	55	67	83	113
--	--	--	--	23	18	--	--	--	--	41	68	51	47
--	--	--	--	51	1	--	--	--	--	74	118	99	101
--	5	--	--	10	2	51	37	--	3	170	155	155	159
12	8	8	2	203	161	249	173	23	30	1,781	2,185	2,033	1,586
2	--	--	12	282	377	--	43	--	5	513	702	[4]569	828
--	--	--	--	--	--	56	68	--	3	93	128	132	143
--	--	--	11	70	70	--	--	--	--	55	56	70	81
4	5	2	17	59	73	--	--	--	--	197	235	134	148
6	5	2	40	411	520	56	111	--	8	858	1,121	[4]905	1,200
--	--	--	--	20	19	--	--	--	--	[5]25	[5]28	20	19
--	6	--	16	XX	XX	36	--	16	13	3,770	4,367	3,702	4,539
--	6	--	16	20	19	36	--	16	13	3,795	4,395	3,722	4,558
--	--	--	--	45	37	--	--	--	--	112	138	109	97
--	--	--	--	75	156	16	17	--	--	219	175	123	175
--	--	--	--	120	193	16	17	--	--	331	313	232	272
--	--	--	--	--	--	55	36	--	--	171	230	166	152
--	--	6	15	5	6	105	108	XX	XX	992	768	324	253
--	--	--	--	--	--	43	20	46	68	256	204	147	58
--	--	5	9	18	3	--	--	--	3	135	114	[4]119	161
XX	XX	2	8	--	--	66	35	--	2	209	228	247	240
--	--	2	7	--	--	28	40	20	29	170	210	[4]160	173
--	--	14	42	--	18	157	118	--	49	587	513	[6]585	499
--	--	6	43	4	14	76	79	--	8	355	442	[4]415	480
15	12	13	41	--	--	--	--	55	21	126	186	212	221
15	12	48	165	27	41	530	436	121	180	3,001	2,895	[4]2,375	2,237
--	--	--	--	--	--	206	169	--	--	538	521	762	701
--	--	--	--	--	--	381	242	--	--	347	397	597	545
--	--	--	--	--	--	1,131	1,214	--	7	1,503	1,481	1,751	1,734
--	--	--	--	--	--	46	73	--	--	229	314	158	202
1	--	--	--	--	--	66	105	--	--	103	91	157	187
1	--	--	--	--	--	1,830	1,803	--	7	2,720	2,804	3,425	3,369
65	60	88	263	784	937	2,717	2,540	186	258	12,766	14,054	[4]13,024	13,525

Table 14.—World trade in sulfates of potash[1 2]

(Thousand short tons, of K_2O equivalent)

Importing areas	Source countries															
	Belgium		West Germany		East Germany		Italy		United States		Spain		Total			
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1973	1974	1975	1976
Africa:																
Algeria	--	--	--	--	--	--	24	17	--	--	14	11	43	30	38	28
Morocco	10	8	1	--	--	--	7	5	--	--	10	10	10	21	28	23
South Africa, Republic of	16	4	17	19	--	--	--	--	--	--	--	--	33	30	33	23
Other	--	8	1	--	--	--	--	7	--	--	--	--	3	2	1	15
Total Africa	26	20	19	19	--	--	31	29	--	--	24	21	89	83	100	89
Asia:																
Japan	23	27	51	17	--	--	--	--	46	40	2	--	69	115	122	84
Korea, South	--	--	--	--	--	--	12	3	12	15	--	--	11	5	24	18
Other	--	3	10	12	--	--	--	5	5	2	--	--	6	9	15	22
Total Asia	23	30	61	29	--	--	12	8	63	57	2	--	86	129	161	124
Latin America:																
Brazil	--	5	9	3	--	1	2	--	8	16	--	2	13	21	19	27
Colombia	--	--	3	--	--	--	--	--	9	2	2	--	5	6	14	2
Cuba	--	3	7	6	8	7	--	--	--	--	--	--	14	16	15	16
Mexico	--	--	--	--	--	--	--	--	9	15	--	2	12	6	9	17
Other	--	--	1	--	--	--	4	5	4	11	--	--	12	25	9	16
Total Latin America	--	8	20	9	8	8	6	5	30	44	2	4	56	74	66	78
North America:																
Canada	--	--	--	--	--	--	--	--	15	16	--	--	25	28	15	16
United States	16	13	23	22	--	--	--	6	XX	XX	--	--	33	27	39	41
Total North America	16	13	23	22	--	--	--	6	15	16	--	--	58	55	54	57
Oceania:	--	--	3	--	--	--	--	--	6	7	--	--	8	8	9	7
Western Europe:																
Austria	--	--	14	14	5	6	--	--	--	--	--	--	26	21	19	20
Belgium	XX	XX	16	21	--	--	--	--	--	--	--	--	11	9	16	21
Denmark	--	--	1	--	--	--	--	--	--	--	--	--	--	1	1	--
France	46	68	4	5	--	--	--	--	--	--	--	--	54	71	50	73
Greece	--	10	--	7	--	--	12	12	--	--	4	10	19	21	16	39
Netherlands	20	29	22	22	1	1	--	--	--	--	--	--	50	59	43	52
Norway	45	43	--	--	--	--	--	--	--	--	--	--	55	53	45	43

Sweden	--	--	16	13	--	2	--	--	--	--	--	--	16	24	16	15
Other	10	30	19	18	8	4	--	--	--	--	--	--	59	52	37	52
Total Western Europe	121	180	92	100	14	13	12	12	--	--	4	10	290	311	243	315
Eastern Europe:																
Czechoslovakia	--	--	13	--	--	37	--	--	--	--	--	--	24	18	13	37
Hungary	--	--	17	8	2	26	--	--	--	--	--	--	8	13	19	34
Poland	--	7	8	14	8	10	--	--	--	--	--	--	37	31	16	31
U.S.S.R.	--	--	--	--	20	--	--	--	--	--	--	--	--	--	20	--
Yugoslavia	--	--	1	3	11	14	--	--	--	--	--	--	4	5	12	7
Other	--	--	--	--	6	6	1	--	--	--	--	--	10	8	7	6
Total Eastern Europe	--	7	39	25	47	83	1	--	--	--	--	--	83	75	87	115
World total	186	258	257	204	69	104	62	60	114	124	32	35	670	735	720	785

XX Not applicable.
[1]Data on U.S. exports supplied by the Potash Institute; data on exports from other countries supplied by ISMA, Ltd., Paris, France.
[2]Includes potassium sulfate and potassium magnesium sulfate.

Congo, People's Republic of the.— Production of potash from sylvinite beds continued to become increasingly less competitive and profitable because of technical and political problems. The beds were folded and irregular in thickness. Production fell by approximately 10% in 1976 to about 0.28 million tons of K_2O equivalent. Compagnie des Potasses du Congo was searching for new investors to develop the extensive and potentially more profitable Congolese carnallite deposits. The French Government attempted, without success, to disengage itself from the Congolese potash production industry in 1976.

France.—The 1975 downtrend in French potash production continued into 1976 because of high French inventories and continuing low demand in Western Europe. Production decreased 16% to 1.77 million tons of K_2O equivalent. Producers' inventories decreased 14% to 0.33 million tons of K_2O. However, an encouraging revival in the domestic market occurred near yearend.

Combined exports from France and the People's Republic of the Congo, 60% of which went to Western Europe, decreased 13% to 0.52 million tons of K_2O.

An agreement to control discharge by the Alsatian potash industry of byproduct salt into the Rhine River was reached by France, West Germany, Luxembourg, the Netherlands, and Switzerland. Discharge from the French mines was to be limited immediately to 130 kilograms of chloride ion per second, and this pollution was to be reduced, in three stages, by nearly 50% over a 6-year period. The cost of the first stage, about $25 million, was to be borne mainly by the Netherlands, France, and West Germany.

The Bollwiller mine, smallest of the four French potash mines, was closed in 1976.

Germany, East— Production and exports of potash continued to increase moderately; production increased 5% to about 3.5 million tons of K_2O equivalent, and total exports increased 6% to 2.54 million tons of K_2O. Export distribution was 60% to Eastern Europe, mostly Poland and Czechoslovakia, 22% to Western Europe, 9% to Asia, and the balance to Latin America. Exports to Latin America increased 80%, compared with that of 1975. About 4%, on a K_2O basis, of the total exports was sulfate of potash.

Muriate grade had improved since 1970 so that three-quarters of 1975 production was 60% K_2O quality. It was realized that production of coarser grades of muriate must increase in order to penetrate the U.S. market. Potassium sulfate comprised only 2% of production. Projected 1980 potash production was about 4.0 million tons.

Germany, West—The 1975 downtrend in West German potash production continued into 1976 because of continuing low demand in Western Europe. Production, 14% as sulfates and the balance as muriate, decreased 8% to 2.24 million tons of K_2O equivalent. Fifty-six percent of the muriate produced was premium 60% K_2O material; the balance contained less than 60% K_2O. Potash producers' stocks were controlled and held at a near normal level. Domestic consumption increased 6% to 1.28 million tons of K_2O; 10% was used in the chemical and related industries, and the balance was used for agricultural purposes. Exports, 24% of which was sulfates, decreased 13% to 0.86 million tons of K_2O; the export breakdown by world area was 58% to Western Europe, 20% to Asia, 10% to Latin America, and 12% to other.

Kali und Saltz G.m.b.H., the major producer in West Germany, drilled one borehole on the northern shore of Steinhuder Meer, west of Hannover, with the view of exploiting the potash deposit there.

The Ronnenberg mine near Hannover, with a reported annual capacity of 150,000 tons of K_2O, was closed permanently because of flooding.

Israel.—Exports, the main outlet for Israeli potash, continued to decline, decreasing 7% in 1976 to 0.38 million tons of K_2O equivalent. Producers' inventories continued to increase despite a decrease in production late in 1976. Total potash production, all muriate, decreased 2% to 0.75 million tons of K_2O in 1976 after having increased 15% in 1975.

Haifa Chemicals completed an expansion of its plant in Haifa, which produced a pure grade of potassium nitrate from potassium chloride. The new capacity was reportedly 240,000 tons per year, equivalent to approximately 110,000 tons of K_2O per year. Most of this increased production was destined for export.

Italy.—Italy continued to rely on imports for most of its potash supply. Net imports increased 18% to 0.18 million short tons of K_2O equivalent. Potash production decreased 8% to 0.15 million tons.

Laos.—Before being evicted from Laos, the U.S. Agency for International Development outlined a sylvinite bed 10 to 15 feet thick in a deposit along the Mekong River flats near Vientiane. The depth of the bed ranged from 300 to 1,400 feet. Reserves and resources were estimated to be 21 and 44 million short tons of K_2O equivalent, respectively.

Peru.—The Government of Peru was reportedly undertaking pilot plant tests for extraction of potassium chloride from brine deposits in the western half of the Sechura Desert. Estimated reserves were reported to be about 10 million tons of K_2O equivalent.

Spain.—Spanish potash production continued to increase in 1976, rising 14% to 0.58 million tons of K_2O equivalent or near full capacity. About one-sixth of this production was potassium sulfates. Exports, 63% to Western Europe, about tripled to 0.26 million tons of K_2O.

Thailand.—A 145-foot-thick bed of high-grade carnallite was outlined in northeastern Thailand near the Laos border. No significant quantities of sylvinite had been located, although its presence was inferred. The Thailand Department of Mineral Resources partially completed a program for exploration drilling. Outside investment was sought for commercial development of these resources. Total reserves and resources of potash in Thailand were estimated to be 60 million and 10 billion tons of K_2O equivalent, respectively.

U.S.S.R.—Both production and exports of potash reportedly increased sharply over the period 1970 to 1975; annual increases averaged 16% for production and 14% for exports. Production increases were below target in 1976; producton rose only 4% to 9.1 million tons of K_2O equivalent, reportedly because of overestimated demand in the U.S.S.R. grainbelt. Reported exports for 1976 decreased 7% to 2.54 million tons of K_2O. Export distribution was 71% to Eastern Europe, mostly Poland, 17% to Western Europe, 7% to Asia, and 5% to other areas.

Although 28% of potash production was exported, additional foreign markets were being sought, particularly where U.S.S.R. potash could be exchanged for phosphate fertilizers. Major facility expansions were underway in the Uralkali Combine. Two complexes, Berezniki 4 and Novosolikamsk, each with a nameplate capacity of 3.2 million short tons K_2O, were scheduled to go onstream by the end of 1977 and 1978, respectively. Production forecast for 1980 was reported to be near 13 million tons of K_2O.

The U.S.S.R. was reportedly procuring 16 large compacting presses, with a total capacity of about 1 million tons of K_2O, for conversion of standard muriate into granular muriate of potash to enhance its salability in Western markets. Granular muriate was being offered in the international market by the end of 1976.

Longwall mining was used in some of the mines in the Starobinsk deposit at Soligorsk. Mineral recovery in this rich sylvinite deposit was increased, as a result of this longwalling, from 45% to 70%, and the average K_2O content of the ore was increased from 26% to 36% K_2O.

A pilot solution-mining plant began operation at Gaurdak in Turkmenistan.

TECHNOLOGY

Research continued by the Federal Bureau of Mines and industry on removal of insoluble slimes from high-clay Carlsbad sylvinite ores prior to froth flotation of muriate of potash from halite. Bureau studies indicated that removal of insolubles by a selective flocculation-flotation procedure should be an improvement over standard mechanical desliming techniques; potash loss in the clay-slime tailings was decreased significantly.

Table 15.—Marketable potash: World production by country

(Thousand short tons, of K_2O equivalent)

Country[1]	1974	1975	1976[p]
Canada	6,041	5,992	5,510
Chile	14	13	16
China, People's Republic of[e 2]	420	440	500
Congo	[r]314	305	280
France	[r]2,296	2,116	1,768
Germany, East	3,157	3,328	3,484
Germany, West	2,888	2,450	2,244
Israel	669	767	750
Italy	169	160	147
Spain	436	506	577
United Kingdom	[r]12	17	50
U.S.S.R.[e]	7,260	8,757	9,150
United States	2,552	2,501	2,400
Total	[r]26,228	27,352	26,876

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, Australia produced small, unreported quantities of marketable potash in 1974, 1975, and 1976.

[2]Data for year ending June 30 as reported in the British Sulphur Corp., Ltd., Statistical Supplement No. 14, November-December, 1976, London, pp. 18-19.

Pumice and Volcanic Cinder

By A. C. Meisinger[1]

A record high quantity of 4.13 million tons of pumiceous materials (pumice, pumicite, volcanic cinder, and scoria) was produced in the United States in 1976. Value of production was $10.5 million, the second highest value on record, compared with $11.2 million in 1975. More crude material was sold or used at a lower unit value per ton to partially account for the 7% decrease in total value compared with that of 1975.

Three States— Arizona, California, and Oregon— accounted for 64% of the total U.S. production of pumiceous materials. California led all producing States with 95 active operations. Volcanic cinder, including scoria, comprised 78% of the domestic output of pumiceous materials in 1976, and was produced in 10 of the 11 producing States. Combined use of pumiceous materials for road construction and concrete aggregate and admixtures comprised 79% of U.S. consumption (excluding imports) compared with 84% in 1975.

Exports of domestic pumice and pumicite declined for the third consecutive year, but only 19% in quantity compared with 57% in 1975. The principal export destination was Canada (53%), followed by West Germany and Israel.

Imports of pumice in 1976, primarily from Italy and Greece, totaled 81,401 tons, the lowest figure since 1962, and represented a 44% decrease compared with 1975 imports. Pumice imported for use in manufacturing concrete masonry products decreased 46% and was the primary factor for the overall decline in U.S. imports for the second consecutive year.

DOMESTIC PRODUCTION

Production of pumiceous materials in 1976 totaled 4.13 million tons valued at $10.5 million, compared with 3.89 million tons valued at $11.2 million in 1975. The record high quantity in 1976 (previous record high was 3.94 million tons in 1974) was attributed to increased production of pumice and pumicite (15% over that of 1975) and a record high of 3.2 million tons of volcanic cinder mined.

Although total production of pumiceous materials increased 6% in quantity over that of 1975, the value declined nearly 7% from the record high value of $11.2 million established in 1975. The decrease in total value was due, in part, to an increase in use of crude pumiceous materials at a lower unit price per ton and a subsequent decrease in prepared material at a lower unit price. Volcanic cinder and scoria comprised 78% of the domestic output of pumiceous materials, compared with 80% in 1975.

Domestic output in 1976 came from 93 individuals, firms, and governmental agencies producing from 259 operations in 11 States, compared with 91 producers and 267 operations in 11 States in 1975. California led all the producing States in number of active operations with 95, followed by Oregon with 68, and Arizona with 40. The combined output of pumiceous materials (primarily volcanic cinder) in Arizona, California, and Oregon in 1976 was 2.6 million tons, or 64% of the national total. Other States with significant output levels of pumiceous materials were Hawaii, Nevada, and New Mexico. Volcanic cinder, including scoria, was produced in 10 of the 11 States and in American Samoa.

[1]Industry economist, Division of Nonmetallic Minerals.

Table 1.—Pumice, pumicite, and volcanic cinder sold or used in the United States[1]

(Thousand short tons and thousand dollars)

Year	Pumice and pumicite		Volcanic cinder		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1972	790	1,878	3,023	4,661	3,813	6,539
1973	824	3,612	3,113	5,269	3,937	8,881
1974	873	3,669	3,064	5,452	3,937	9,121
1975	790	3,493	3,102	7,710	3,892	11,203
1976	906	3,830	3,228	6,636	4,134	10,466

[1]Values f.o.b. mine or mill.

Table 2.—Pumice, pumicite, and volcanic cinder sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1975		1976	
	Quantity	Value	Quantity	Value
Arizona	856	1,294	802	1,240
California	348	2,762	705	3,245
Hawaii	318	912	330	636
Idaho	111	187	W	W
Montana	--	--	5	8
Nevada	W	W	388	763
New Mexico	397	1,280	486	1,560
Oklahoma	1	W	1	W
Oregon	1,470	3,937	1,125	2,311
Utah	17	23	164	264
Other States[1]	374	808	128	439
Total	3,892	11,203	4,134	10,466
American Samoa	15	15	47	30

W Withheld to avoid disclosing individual company confidential data. Included with "Other States."
[1]Colorado, Idaho (1976), Kansas (1975), Nevada (1975), and Oklahoma (value only).

CONSUMPTION AND USES

The combined use of domestic pumiceous materials for road construction and concrete admixtures and aggregates accounted for 79% of U.S. consumption compared with 84% in 1975. End uses for the remaining 21% were railroad ballast (8%), landscaping (7%), and other uses including abrasives (6%). Pumiceous materials used as roofing granules accounted for 38% of the total quantity and 49% of the total value of "Other uses" shown in table 3.

The quantity of pumiceous materials used for various abrasive applications increased from 19,000 tons in 1975 to 29,000 tons in 1976, or 53%; that used in landscaping, 84%; in concrete admixtures and aggregates, 12%; and in "Other uses", 83%. Although railroad ballast use remained steady at 310,000 tons in 1976, road construction use decreased 7%. Of the total domestic quantity of pumiceous materials used for road construction, surfacing, and repair, 49% was used by the U.S. Forest Service for road maintenance in National Forests in Arizona, California, New Mexico, and Oregon.

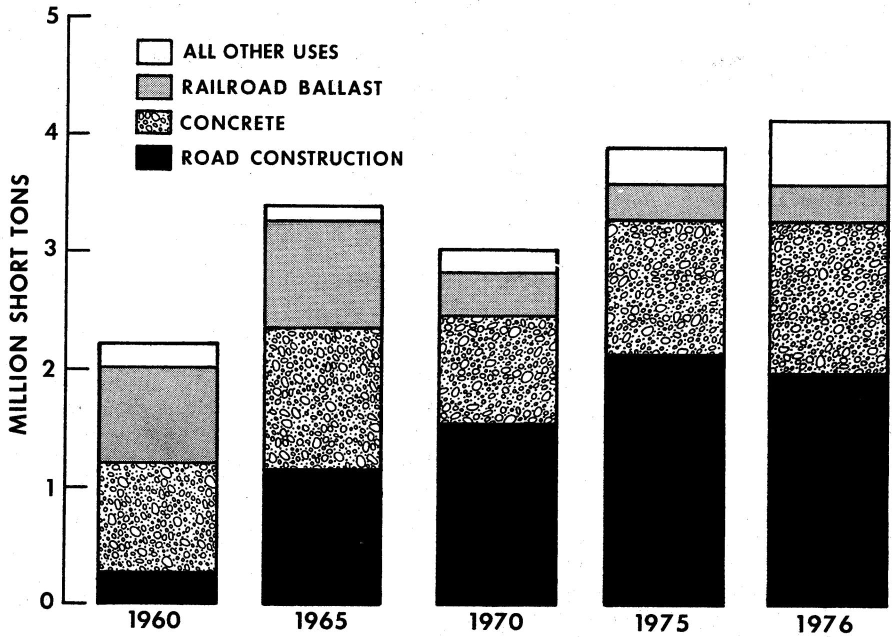

Figure 1.—Pumice and volcanic cinder sold and used by producers in the United States, by use.

Table 3.—Pumice, pumicite, and volcanic cinder sold and used by producers in the United States, by use.

(Thousand short tons and thousand dollars)

Use	1975		1976	
	Quantity	Value	Quantity	Value
Abrasives (includes cleaning and scouring compounds)	r19	578	29	706
Concrete admixture and concrete aggregate	1,158	3,322	1,293	3,397
Landscaping	164	1,257	302	1,340
Railroad ballast	310	455	310	422
Road construction (includes ice control and maintenance)	2,121	4,582	1,980	3,119
Other uses[1]	r120	r1,008	220	1,482
Total	3,892	[2]11,203	4,134	10,466

rRevised.
[1]Includes absorbents, heat-or-cold insulating medium, roofing granules, soil conditioners, and miscellaneous uses.
[2] Data do not add to total shown because of independent rounding.

PRICES

The weighted average value of pumiceous materials produced domestically in 1976 was $2.53 per ton, a 12% decrease compared with that of 1975. The average value for crude material declined from $1.31 per ton to $1.20 per ton, and that for prepared material declined from $4.36 per ton to $4.15 per ton.

Average prices per ton for pumiceous materials in all major uses were lower in 1976 compared with those of 1975. The average price of pumiceous materials used for abrasives (including cleaning and scouring compounds) was $24.34 per ton, a $6.08 decrease; for concrete aggregate and admixtures, $2.63, a $0.24 decrease; for landscaping, $4.44, a $3.22 decrease; for railroad ballast, $1.36, an $0.11 decrease; for road construction material, $1.58, a $0.58 decrease; and for other uses, $6.74, a $1.66 decrease.

According to trade publications, 1976 prices for pumice remained unchanged compared with 1975. Quoted prices in American Paint and Coatings Journal at yearend, per pound, bagged f.o.b. New York or Chicago, were $0.0445 to $0.08 for powdered pumice, and $0.0665 to $0.09 for lump pumice. Quoted prices in Chemical Marketing Reporter at yearend were as follows for domestic grades, bagged in 1-ton lots: Fine, $0.0765 to $0.1140 per pound; medium, $0.1160 per pound; and coarse, $0.094 per pound. Prices from the same source for imported (Italian) silk-screened pumice, bagged in 1-ton lots, were as follows: Fine, $138 per ton; medium, $150 per ton; and coarse, $140 per ton. The price of imported small-lump and large-lump pumice was quoted at $275 per ton.

FOREIGN TRADE

Exports of pumice materials continued to decline from the record high set in 1973 (3,095 tons). Compared with those of 1975, exports decreased 19% in quantity and 74% in value. Exports totaled 1,011 tons in 1976, and went primarily to Canada (53%), West Germany (27%), and Israel (16%).

A substantial decrease in the quantity of pumice imports for the second straight year resulted in the lowest amount (81,401 tons) imported since 1962 (86,504 tons). Compared with that of 1975, the quantity of pumice imports, excluding manufactured, n.s.p.f., decreased 44%, although the value increased 9%. Imports of crude or unmanufactured pumice and wholly or partly manufactured pumice imported, each increased in quantity compared with those of 1975, but that imported for use in the manufacture of concrete masonry products declined 46%, offsetting the gains shown in quantity for the other import classes. Italy and Greece continued to be the major import sources.

Table 4.—U.S. exports of pumice

Year	Quantity (short tons)	Value (thousands)
1973	3,095	$765
1974	2,911	1,211
1975	1,252	1,027
1976	1,011	271

Table 5.—U.S. imports for consumption of pumice, by class and country

Country	Crude or unmanufactured		Wholly or partly manufactured		Used in the manufacture of concrete masonry products		Manufactured n.s.p.f.
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Value (thousands)
1975:							
Canada	--	--	120	$7	--	--	$3
Greece	--	--	--	--	131,998	$298	--
Italy	3,260	$77	555	43	9,425	32	9
Mexico	--	--	--	--	22	(2)	58
Other[1]	--	--	--	--	--	--	6
Total	3,260	77	675	50	141,445	330	76
1976:							
Austria	--	--	--	--	--	--	7
Canada	229	46	--	--	--	--	10
China, People's Republic of	--	--	--	--	--	--	10
Greece	--	--	1	(2)	25,794	46	1
Italy	3,115	102	1,108	86	51,154	217	19
Netherlands	--	--	--	--	--	--	9
Other[3]	--	--	(2)	(2)	--	--	14
Total	3,344	148	1,109	86	76,948	263	70

[1]Austria, Japan, the United Kingdom, and Taiwan.
[2]Less than 1/2 unit.
[3]Japan, Mexico, the United Kingdom, Taiwan, and West Germany.

Pumice stone, TSUS No. 519.05, for use in concrete products, continued to be admitted into the United States duty-free. Duty rates (unchanged from 1975) for other pumice products at yearend were as follows: TSUS No. 519.11, crude or crushed, valued not over $15 per ton, 0.02 cent per pound; TSUS No. 519.14, crude or crushed, valued over $15 per ton, 0.04 cent per pound; TSUS No. 519.31, in grains or ground, pulverized or refined, 0.17 cent per pound; and TSUS No. 519.93, millstones, abrasive wheels, and abrasive articles, n.s.p.f., and 523.61 articles, n.s.p.f., 7% ad valorem.

WORLD REVIEW

Portugal.—A geological survey on the Island of São Miguel in the Azores has indicated approximately 10 million tons of pumice located on the mountainous southern slopes of a volcanic crater near the village of Sete Cidades. Plans were reportedly underway for commercial development of the deposits.

United Kingdom.—A significant increase in imports of pumice by the United Kingdom from Italy, Greece, and West Germany was achieved in 1976 to meet the growing demand for pumiceous construction material. Pumice imports increased 145% (about 307,000 tons) compared with those of 1975. Italy and Greece supplied nearly 97%.

Table 6.—Pumice and related volcanic materials: World production by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
Argentina[2]	[r]73	75	[e]75
Austria: Pozzolan	20	14	13
Cape Verde Islands: Pozzolan[e]	17	17	17
Chile: Pozzolan	[r]163	[r] [e]165	109
Costa Rica[e]	2	2	1
Dominica: Pumice and volcanic ash	[r]20	117	[e]120
Egypt	(3)	[e](3)	[e](3)
France:			
Pumice[e]	[r]2	(4)	--
Pozzolan and lapilli	[r]837	759	791
Germany, West:			
Pumice (marketable)	2,316	2,111	2,553
Pozzolan	[e]220	144	109
Greece:			
Pumice	[r]577	580	402
Pozzolan	905	946	935
Guadeloupe: Pozzolan	193	220	[e]220
Guatemala: Volcanic ash (for cement)	[e]35	17	26
Iceland[5]	8	4	2
Italy:			
Pumice and pumiceous lapilli	980	[e]1,100	[e]1,100
Pozzolan	6,224	[r] [e]6,600	[e]6,600
Martinique: Pumice	73	86	[e]90
New Zealand	78	42	55
Spain[6]	212	153	[e]154
United States (sold or used by producers):			
Pumice and pumicite	873	790	906
Volcanic cinder[7]	3,091	3,117	3,275
Total	[r]16,919	17,059	17,553

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Pumice is also produced in Iran, Japan, Mexico, Turkey, and the U.S.S.R. (sizable quantity), but data on production are not available.
[2]Unspecified volcanic materials produced mainly for use in construction products.
[3]Less than 1/2 unit.
[4]Revised to none.
[5]Exports.
[6]Includes Canary Islands.
[7]Includes American Samoa.

Rare-Earth Minerals and Metals

By Martha L. Kahn[1]

Production of rare-earth oxide (REO) contained in bastnäsite and monazite concentrates decreased about 13% in 1976; however, apparent domestic consumption of rare earths in most industries increased. The overall end-use consumption pattern remained similar to that of 1975. Petroleum catalysts continued to be the major consumer, with metallurgical applications second. The ceramic and glass industries were also major consumers.

Molycorp, Inc., and the Davison Div. of W. R. Grace & Co. continued to be the major processors of rare earths. Production of rare-earth compounds and metals was adequate to meet market demand. There was a slight increase in industrial stocks during the year.

U.S. exports of rare earths increased in 1976, but total REO imported decreased from the 1975 level. Monazite was imported from Malaysia; compounds and metals were imported mostly from Australia, Austria, Brazil, France, Japan, West Germany, and the United Kingdom; and yttrium concentrate was imported mostly from Canada.

Legislation and Government Programs.—At yearend 1976, a total of 7,174 short tons REO equivalent was held in the General Services Administration (GSA) stockpile. Disposals for the year totaled 55 tons REO equivalent. Government stocks of yttrium oxide (Y_2O_3) remained unchanged at 237 pounds.

DOMESTIC PRODUCTION

Concentrate.—Domestic production of REO in bastnäsite and monazite concentrates decreased about 13% in 1976 from the 1975 level. Bastnäsite continued to be the major source of rare earths; the remainder, less than 10%, was produced from monazite.

According to Molycorp's annual report, its Mountain Pass, Calif., operation produced 14,500 short tons of REO contained in bastnäsite concentrate during 1976; 1975 production was 16,500 tons.

Titanium Enterprises, owned jointly by American Cyanamid Co. and Union Camp Corp., recovered monazite as a byproduct of mining a beach sand deposit for titanium minerals and zircon, near Green Cove Springs, Fla. During 1976, monazite production increased substantially.

The only other domestic producer of monazite was Humphreys Mining Co. Again monazite was recovered as a byproduct of heavy-mineral beach sand mining. The dredging operation was located near Hilliard, Fla., and the titanium concentrates were trucked to the company dry plant at

[1]Physical scientist, Division of Nonferrous Metals.

Folkston, Ga., for processing. Monazite production decreased in 1976 from the 1975 level, due to the mining of titanium sands of lower monazite content.

Significant concentrations of rare earths, associated with uranium and thorium in the mineral allanite were discovered[2] on Seward Peninsula in Western Alaska by a U.S. Geological Survey field party. Samples of the mineralized rock, which was associated with alkaline dikes in a 100-square-mile area contained over 2% rare-earth elements.

Buttes Gas and Oil Co. continued feasibility and pilot-plant studies of its southwestern Colorado titanium prospect.[3] The ore mineral, perovskite, contained significant amounts of rare-earth elements that could be recovered. Kerr-McGee Chemical Corp. reported 74,000 tons of indicated recoverable monazite contained in its heavy-mineral sand deposit in Benton County, Tenn.

Compounds and Metals.—In 1976, there were two major processors and producers of rare-earth compounds, Molycorp and the Davison Div. of W. R. Grace & Co., Chattanooga, Tenn. Molycorp, with processing plants at Mountain Pass, Calif., Louviers, Colo., and York, Pa., continued to be the principal domestic producer. Molycorp's sales increased significantly to $27.2 million, compared with $18.9 million in 1975.[4]

A 3-year program to expand mill and chemical-plant production capacities at Mountain Pass was completed at yearend 1975. The new 200-ton-per-day bastnäsite thickening, filtering, and drying section at the mill began processing material in January 1976. A lanthanum concentrate dryer at the chemical plant also became fully operational in early 1976. The new capacity of the mill and chemical plant was 60 million and 30 million pounds, respectively, of rare-earth oxide.

Producers of high-purity rare-earth oxides and compounds were Molycorp; W. R. Grace & Co.; the Research Chemicals Div. of Nucor Corp., Phoenix, Ariz.; Atomergic Chemetals Corp., Plainview, N.Y.; and Transelco Inc., Penn Yan, N.Y.

Mischmetal production increased about 23% in 1976 from the 1975 level. Mischmetal shipments from primary producers also increased. Three domestic companies that produced mischmetal during 1976 were as follows: Ronson Metals Corp., Newark, N.J.; Reactive Metals and Alloys Corp., (REMACOR), West Pittsburgh, Pa.; and Rare Earth Metals Co. of America, (REMCOA), owned jointly by Aluminum Co. of America and Molycorp., Arnold, Pa. REMCOA produced mischmetal from its 125-ton-per-year demonstration unit at the beginning of the year.

Rare-earth ferrosilicon alloys were produced by three companies: Foote Mineral Co., Exton, Pa.; Ohio Ferro-Alloys Corp., Canton, Ohio; and Union Carbide Corp., Alloy, W. Va.

Nucor was the major producer of high-purity rare-earth metals, and Molycorp was the predominate producer of yttrium compounds. The yttrium was processed from yttrium rare-earth concentrates imported from Canada.

CONSUMPTION AND USES

Domestic rare-earth processors consumed an estimated 14,200 tons of REO contained in raw materials in 1976. Consumption of bastnäsite decreased about 17%; however, consumption of monazite increased more than 100%. Shipments of rare earth and yttrium products from primary processing plants to domestic end-use consumers were about 9,700 tons contained REO, valued at about $37 million.

The approximate distribution of rare earth and yttrium consumption by end use, based on information supplied by primary processors and certain consumers, was as follows: Petroleum cracking catalysts, 43%; metallurgical, including nodular iron and steel, other alloys and mischmetal, 35%; ceramics and glass, 14%; and miscellaneous, including electrical, arc carbons, and research 8%. High-purity rare earth and yttrium oxides and metals represented less than 2% of the total weight of shipments; however, such materials comprised a much larger proportion of the value of total shipments.

Domestic yttrium processors consumed an estimated 120 tons of Y_2O_3 contained in raw materials in 1976, compared with 95 tons in 1975. This increase was attributed to

[2]Miller, T. P., R. L. Elliot, W. I. Finch, and R. A. Brooks. Preliminary Report on Uranium, Thorium and Rare-Earth-Bearing Rocks Near Golovin, Alaska. U.S. Geol. Survey Open File Rept. 76-710, Sept. 27, 1976, 13 pp.

[3]Engineering and Mining Journal. International Directory Mining Activity Digest. New Development Highlight. V. 2, No. 10, Mar. 12, 1976, p. 1.

[4]Molycorp Inc. 1976 Annual Report, p. 5.

greater demand by manufacturers of color television phosphors.

The use of rare-earth zeolites in cracking catalysts to increase gasoline yields from petroleum feedstocks continued to be the single largest use of rare earths. Metallurgical usage of rare-earth elements, mostly as additives to ductile iron and steel, was stable. Rare-earth elements are added to high-strength low-alloy (HSLA) steels in mischmetal or rare-earth silicides.

The production of lighter and striker flints continued to be a major consumer of mischmetal. Other rare-earth alloys and metals were used in the production of high-temperature alloys and superalloys.

The glass industry continued to be a major consumer of rare-earth compounds, particularly cerium oxide. The established uses of cerium oxide are as an abrasive for polishing glass; an additive in eyeglasses, television tubes, and camera lenses; and as a decolorizing agent in refining clear glass. Other rare-earth oxides of praseodymium, erbium, holmium, and neodymium, were used as colorants in glass. Lanthanum oxide was used to improve the refractive quality of camera lenses.

The use of rare earths in X-ray phosphors increased in 1976. Terbium-activated gadolinium or lanthanum oxysulfide phosphors were used to intensify X-ray screen images. Because of the effectiveness of these phosphors, they allowed speedup of X-ray film exposure, which reduced patient X-ray dosages by as much as 80%.

Yttrium and europium oxide were consumed as key constituents of the red phosphor in color television tubes.

Synthetic garnets composed of yttrium-aluminum (YAG), yttrium-iron (YIG), gadolinium-aluminum (GAG), and gadolinium-iron (GIG). were used as microwave filters and control devices, as simulated diamonds, and, when doped with neodymium or erbium, in lasers. Minor quantities of gadolinium-gallium garnets (GGG) in thin-film, magnetic-bubble memory systems were used in communication and computer systems, including a 100-million-bit-capacity data recorder being built by the Autonetics Division of Rockwell International, and a recorded message machine at one of Michigan Bell Telephone Co.'s Detroit switching offices.

Significant quantities of rare-earth oxides and fluorides were used in carbon-arc lamps, which emit a high-intensity white light used in searchlights and the motion picture industry.

The consumption of rare-earth-cobalt alloys in permanent magnets continued to expand. These high-energy magnets, which are two to three times more powerful than conventional permanent magnets, are used mainly in small electric motors and generators, electric wrist watches, and electronic tubes. Samarium and rare-earth alloys were predominately combined with cobalt for magnet production. A new use of rare earths in 1976 was as phosphors in fluorescent lamps, which emit white light made up of only three narrow spectral bands (blue, green, and red). The blue phosphor is strontium chlorapatite-europium, and the red phosphor is yttrium oxide-europium. The new lamps were reported to offer about 30% more light output, greater brightness and visual clarity, and better color rendition than other fluorescent lamps.[5] It was estimated [6] that if this new lamp were to capture only 10% of the fluorescent bulb market, it would create a demand for high-purity rare-earth oxides roughly equivalent to that of the color television industry.

STOCKS

Stocks of rare earths in all forms, held by 15 rare-earth producing, processing, or consuming companies increased slightly during 1976.

At yearend 1976, bastnäsite concentrate stocks held by the principal producer and three other chemical processors increased by about 18% compared with the levels at the beginning of the year. Monazite stocks decreased 35% during the year. Stocks of compounds and mixtures of rare earths held by 10 companies increased about 6% during 1976. Mischmetal stocks increased about 16% during 1976. Stocks of high-purity metals held by three companies decreased about 46% in 1976.

[5]Cannon, J. G . Rare Earths - '76 Was Slow; Pickup Seen for '77. Eng. & Min. J., v. 178, No. 3, March 1977, pp. 183-188.

[6]The Value Line Investment Survey. Arnold Bernhard & Co., Inc. Pt. 3, 4th ed., Jan. 28, 1977, p. 587.

PRICES

Prices for domestic monazite increased about 25% during 1976. The average declared value of imported monazite, all from Malaysia, decreased slightly to $205 per short ton from $207 per short ton in 1975. The average price per metric ton of Australian monazite (minimum 60% REO plus ThO_2) as quoted in Metal Bulletin (London) remained constant during 1976 at $A170 to $A185 However, the price of Australian monazite in U.S. dollars decreased about 17% in December 1976 because of the devaluation of Australian currency. Quoted prices for Malaysian xenotime concentrate containing a minimum of 25% Y_2O_3 remained at the 1975 level of $2 to $3 per pound c.i.f.

Prices for unleached, leached, and calcined bastnäsite containing 55% to 60%, 68% to 72%, and 85% to 90% REO, respectively, were increased by yearend from 45, 50, and 60 cents, respectively, to 50, 58, and 68 cents per pound REO, respectively, f.o.b. Mountain Pass or Nipton, Calif., in 100-pound paper bags or 55-gallon steel drums in truckload or carload lots.

Prices of rare-earth compounds and metals remained at about the 1975 level. Most prices of rare-earth products were negotiable if purchased in large quantities. A sampling of quoted prices at yearend of rare-earth compounds, per pound f.o.b. plant were as follows: Lanthanum-rare-earth hydrate, 75% REO, $0.75; rare-earth chloride, 46% REO, $0.55; rare-earth carbonate, 65% REO, $1.30; and cerium fluoride, 62% REO, $1.55.

Prices quoted in the American Metal Market for 1-pound ingots in 50- to 100-pound lots of 97% didymium and cerium-free mischmetal were $15 and $12, respectively, f.o.b. plant. Mischmetal, 99.8%, was quoted at $3.45 per pound same basis. Quoted prices, in dollars per pound, of rare-earth metals for magnet use remained at the 1975 level: Cerium, $18; lanthanum, $27.50; praseodymium, $62.50; and samarium, $75 (all 99% purity and in 10- to 100-pound amounts).

Table 1.—Prices of high-purity rare-earth oxides, salts, and metals in 1976 [1]

(Dollars per pound)

Element	Oxide[2]	Salts[3]	Metal[4]
Cerium	6.50	12.00	50.00
Dysprosium	40.00	27.00	130.00
Erbium	45.00	27.00	160.00
Europium	515.00	225.00	3,000.00
Gadolinium	50.00	26.00	220.00
Holmium	120.00	80.00	300.00
Lanthanum	5.00	12.00	50.00
Lutetium	2,000.00	1,100.00	6,000.00
Neodymium	18.00	12.00	110.00
Praseodymium	32.00	16.00	170.00
Samarium	32.00	16.00	155.00
Terbium	350.00	175.00	845.00
Thulium	1,000.00	550.00	2,600.00
Ytterbium	85.00	70.00	240.00
Yttrium	30.00	15.00	150.00

[1]Research Chemicals, Nucor Corp., f.o.b. Phoenix, Ariz. For large quantities, prices may be negotiable. Other producers may have different prices on some items.
[2]Minimum 99.9% purity, more than 1 pound.
[3]Minimum 99.9% purity, more than 1 pound; includes chlorides, nitrates, sulfates, oxalates, and acetates.
[4]Minimum 1 pound, ingot form.

FOREIGN TRADE

Exports of bastnäsite concentrates contained about 2,700 tons of REO, according to Molycorp, the sole producer. Exports of ferrocerium and other pyrophoric alloys to the Republic of Korea, Canada, and 28 other countries increased 19% to 119,792 pounds valued at $334,973. The average unit value was $2.80 per pound. Shipments of compounds and mixtures of rare-earth metals, including yttrium and scandium, went to 33 countries. Japan and West Germany received about 56% of the 631,593 pounds, valued at $5,015,239. This was a 57% decrease in shipments from 1975.

Monazite imports (table 2), all from Malaysia, decreased to 2,103 tons with an average unit value of $205 per ton. Imports of cerium oxide, predominately from France, increased to 814 pounds valued at $6,713 in 1976 compared with 624 pounds valued at $5,216 in 1975. The average unit value was $8.25 per pound. Imports of cerium chloride, from West Germany, totaled 4,409 pounds, with an average unit price of 72 cents per pound. Imports of other cerium compounds, predominately from France, totaled 13,055 pounds valued at $57,178. The unit value ranged from $3.93 (France) to $154.69 (West Germany) per pound.

Rare-earth metals, scandium, and yttrium imports for consumption totaled 74 pounds valued at $9,131. In addition, there were general imports of rare-earth metals, scandium, and yttrium from the U.S.S.R. totaling 4,483 pounds valued at $141,132.

Imports of ferrocerium and other pyrophoric alloys increased 19% to 40,259 pounds valued at $166,978. Japan supplied 79% of the total valued at $118,824, followed by France with 14% valued at $33,589. Other suppliers were the United Kingdom, India, Austria, and Switzerland. Imports of rare-earth metals and alloys, predominately from Australia and Brazil, increased 123% to 43,509 pounds valued at $70,612. The average unit value decreased from $5.73 per pound in 1975 to $1.62 per pound in 1976 owing to increased mischmetal imports from Australia. Imports of other rare-earth-metal alloys, entirely from West Germany, totaled 1,044 pounds valued at $3,387.

Table 2.—U.S. imports for consumption of monazite

Country	1972		1973		1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Malaysia	894	$89	1,991	$244	984	$154	r2,462	r$508	2,103	$431
Thailand	--	--	110	10	336	47	r103	r24	--	--
Total	894	89	2,101	254	1,320	201	2,565	532	2,103	431
REO content[e]	492	XX	1,156	XX	726	XX	1,411	XX	1,157	XX

[e]Estimate. [r]Revised. XX Not applicable.

Table 3.—U.S. imports for consumption of rare-earth metals[1]

Country	1974		1975		1976	
	Pounds	Value	Pounds	Value	Pounds	Value
Germany, West	641	$27,827	491	$22,592	--	--
Mexico	112	2,331	--	--	--	--
U.S.S.R.	7,785	157,957	2,659	58,336	--	--
United Kingdom	4	5,235	57	6,890	74	$9,131
Total	8,542	193,350	3,207	87,818	74	9,131

[1]Including scandium and yttrium.

WORLD REVIEW

The major world sources of rare earths were bastnäsite, which accounted for about 68% of world mine production in 1976, and monazite. Separated compounds and metals of lanthanum through europium were derived mainly from bastnäsite. Separated compounds and metals of the other rare-earth elements and yttrium were derived mainly from monozite. Many countries had limited rare-earth-processing capacity; however, only five countries—France, the United Kingdom, Japan, U.S.S.R., and the United States—produced a full range of rare-earth compounds and metals in commercial quantities.

Table 4.—Monazite concentrates: World production, by country

(Short tons)

Country[1]	1974	1975	1976[p]
Australia	[r]3,943	4,968	5,016
Brazil	1,318	[r e]1,600	[e]1,600
India[e]	3,300	3,300	3,300
Korea, Republic of[e]	10	10	10
Malaysia[2]	1,965	3,621	2,071
Nigeria	12	[r e]20	[e]20
Sri Lanka	6	[r e]5	1
Thailand	486	405	[e]400
United States	W	W	W
Zaire	261	328	265
Total	[r]11,301	14,257	12,683

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]In addition to the countries listed, Indonesia and North Korea may produce monazite, but information is inadequate to make reliable estimates of output levels.
[2]Exports.

Australia.—According to the Rutile & Zircon Development Assoc., Ltd., the 1976 production of monazite by member companies was as follows, in tons:

State	1974	1975	1976
New South Wales	1,071	1,207	1,089
Queensland	30	685	227
Western Australia	2,550	3,252	3,698
Total	3,651	5,114	5,014

Mary Kathleen Uranium, Ltd., continued work on a pilot plant to recover rare earths from uranium processing operations.[7] Metals Exploration Ltd. and Alliance Oil Development Australia NL announced the discovery of mineral sands containing 800,000 tons of heavy minerals at Cataby, about 90 miles north of Perth.[8] The heavy minerals contain about 1.5% monazite. Associated Minerals Consolidated Ltd. and Western Titanium Ltd., announced merger plans. The two companies produced 2,095 tons of byproduct monazite in 1976.[9] Westralian Sands Ltd., a producer of byproduct monazite, resumed full-scale mining operations at Yoganup.[10] The mine and treatment plant had been on a care and maintenance level due to low demand for ilmenite.

Canada.—Denison Mines, Ltd., reported production of 58,000 pounds of yttrium oxide contained in yttrium-rare-earth concentrate in 1976; all production was exported. This was a 25% decline in production from that in 1975 and was mainly a result of labor problems during 1976. Since the start of operations 17 years ago, a total of 702,000 pounds of yttrium oxide has been produced.[11] The yttrium-rare-earth concentrate, which is a byproduct of uranium mining, contained about as much REO as Y_2O_3.

Germany, West.—Th. Goldschmidt AG of Essen increased its capacity to produce powder form rare-earth cobalt alloys to 50 tons per year. [12] The alloys were for use in permanent magnets.

India.—About 500,000 tons of monazite was estimated to occur in a 15-mile belt in coastal sands in the Ganjam and Puri districts, Orissa State.[13]

Separation of byproduct monazite, by electromagnetic and electrostatic mineral separation techniques, from ilmenite deposits in the Chavara beach sands of Kerala, was under consideration by Kerala Minerals and Metals Ltd.[14]

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[7]Mining Journal. Progress at MKU. V. 286, No. 7334, Mar. 12, 1976, p. 201.
[8]Mining Journal. Mineral Sands at Cataby. V. 287, No. 7353, July 23, 1976, p. 68.
[9]Industrial Minerals. RTZ Reshuffle. V. 110, November 1976, p. 9.
[10]European Chemical News. Newsbriefs. V. 29, No. 752, Sept. 10, 1976, p. 28.
[11]Denison Mines Limited. 1976 Annual Report, p. 5.
[12]Energy and Mineral Resources Research Institute, Iowa State University (Ames, Iowa). Expands Magnet Production. Rare-Earth Inf. Center News, v. 11, No. 4, Dec. 1, 1976, p. 4.
[13]Engineering & Mining Journal. India: Monazite Sand. V. 177, No. 5, May 1976, p. 180.
[14]Minerals & Metals Review. Karala's New Plant. V. 2, No. 5, December 1976, p. 26.

Table 5.—Rare-earth consumption in Japan

(Short tons)

	1975	1976	1977[e]
Y_2O_3: Television phosphors	15	32	26
Eu_2O_3: do.	.9	2	1.6
La_2O_3:			
Optical glass	65	180	180
Ceramic capacitors	55	90	85
CeO_2:			
Decolorizing	100	200	180
Polishing	590	670	650
Mischmetal:			
Lighter flints	130	135	145
Iron and steel	180	290	250
Rare-earth fluorides:			
Arc carbon	60	80	80
Iron and steel	70	60	60
Total	1,266	1,739	1,658

[e] Estimate.

Source: Japan Metal Journal. Demand Prospects of Rare-Earths. V. 7, No. 16, April 18, 1977, p. 7.

Japan.—In 1976, rare-earth demand increased significantly over that of 1975, owing mainly to increased demand for color television sets and transceivers.[15] The United States provided about one-fourth of the total Japanese imports of rare-earth metals and compounds. Rare-earth consumption in Japan for 1975, 1976, and the estimated demand for 1977 is given in table 5.

Malaysia.—Malaysian Rare Earth Corp. (MAREC), a joint venture of Mitsubishi Chemical Industries Ltd., of Japan and Beh Minerals Sendirian Berhad of Ipoh, Perak State, Malaysia, in 1976 became the first chemical company in Malaysia to upgrade locally produced zenotime.[16] The plant's trial run and commissioning occurred in November, and the first overseas shipment took place on November 11, 1976. MAREC planned to produce about 130 tons of a 50% yttrium concentrate per year.

South Africa, Republic of.—The proposed heavy mineral operation north of Richards Bay on the east coast by two companies, Tisand (Pty.) Ltd., and Richards Bay Iron and Titanium (Pty.) Ltd., was scheduled to proceed as soon as financial arrangements were completed. The proposed mining area will be approximately 11 miles long and 2 miles wide. Monazite could be recovered as a byproduct of rutile and zircon mining.

Yemen.—Hunting Geology & Geophysics Ltd., was investigating heavy minerals in beach sands as part of a larger study being performed for the Government.[17] A 2-year program was anticipated.

TECHNOLOGY

Research continued on rare-earth X-ray screen film systems.[18] Compared with systems that do not contain rare-earth elements, rare-earth systems were up to 13 times faster, resulted in less patient exposure, and improved operational parameters. Rare-earth magnet research continued in areas as diverse as magnets in dentures to keep teeth in place, and the use of high-speed (about 190 miles per hour) magnetically levitated vehicles, which have been built and tested in West Germany and Japan.[19] Magnetic bearings with zero friction and the use of rare-earth-cobalt magnets in ironless armature torque motors were also studied.

Research continued on the development of a rare-earth auto-emission-control catalyst that tolerates leaded gasoline.[20] $LaCoO_3$ was found to be an inexpensive material that was not poisoned by tetraethyl lead or lead dibromide or ethylene dibromide, and retained its catalytic activity after exposure to high-temperature surges simulating backfire.

[15] Japan Metal Journal. Demand Prospects of Rare Earths. V. 7, No. 16, Apr. 18, 1977, pp. 6-7.

[16] Energy and Mineral Resources Research Institute, Iowa State University (Ames, Iowa). Who is . . . .The Rare Earth Industry? MAREC. Rare-Earth Inf. Center News, v. 12, No. 2, June 1, 1977, p. 3.

[17] Engineering & Mining Journal. V. 3, No. 11, Apr. 8, 1977. p. 6.

[18] Rossi, P. R., W. R. Hendee, and C. R. Ahrens. An Evaluation of Rare Earth Screen Film Combinations. Radiology, v. 121, No. 2, November 1976, pp. 465-471.

[19] Simpson, P. A. New and Unusual Devices Using Rare Earth-Cobalt Permanent Magnets. Proc. 12th Rare-Earth Res. Conf., Vail, Colo., July 18-22, 1976, 6pp.

[20] Katzman, H., L. Pandolfi, L. A. Pedersen, and W. F. Libby. Lead-Tolerant Auto Exhaust Catalysts. CHEMTECH, v. 6, No. 6, June 1976, pp. 369-371.

A relatively inexpensive crystalline alloy, containing lanthanum, neodymium, praseodymium, and nickel was found to be capable of adsorbing six atoms of hydrogen per molecule. It was suggested that such hydrogen adsorbers could be used in solar heating and cooling of homes, leveling peak-load demands at electric utility companies, for advanced compressor and nonpolluting engine design, safer hydrogen storage at petrochemical, synthetic fuel, and chemical-processing plants, and in offgas purification systems.[21]

Research on rare-earth lasers continued in 1976, with emphasis on nuclear fusion applications.[22] The largest neodymium glass laser in the world was being built. It was to contain 1,000 liters of rare-earth-doped material.[23] The University of Rochester's Laboratory for Laser Energetics launched a 5-year, $46.5 million program to build and test a 10-Kilojoule neodymium glass laser system, which will have a peak power of 20 to 40 terawatts.[24] KMS Fusion continued the only laser fusion research effort by a private company and planned to expand the power of its neodymium glass laser system in 1977 to 4 or 5 terawatts.

The U.S. Air Force manufactured rods as long as 4 inches of anisotropic yttrium aluminate doped with neodymium.[25] These rods are potential replacements for neodymium-doped yttrium-aluminum-garnet (YAG) in solid-state lasers.

Two rare-earth laser devices were on the Industrial Research list of 100 top products of 1976.[26] One of the top products was a new laser ion-host system, consisting of lanthanum beryllate single crystals doped with neodymium, which had advantages over conventional YAG doped with neodymium. The other laser device was an yttrium lithium fluoride crystal doped with holmium used as a pulsed or continuous source of 2-micron laser radiation.

A patent was issued for the extraction of columbium, rare earths, and thorium from pyrochlore.[27] A patent was issued [28] for a method of purifying an atmosphere containing carbon monoxide by passage through a catalyst bed of terbium oxide, in which the carbon monoxide is oxidized to carbon dioxide. The use of a rare-earth catalyst to convert nitrogen and sulfur compounds, created during the dosposal of dynamite-manufacturing wastes, to oxides was under consideration.[29]

A new alloying method, mechanical alloying, in which rare-earth elements can be used was discussed.[30] The base metal and alloying metals are combined in a high-energy ball mill in a nitrogen or inert gas atmosphere, with no lubricant. Mechanical alloying has led to the development of an alloy that combines the moderate-temperature properties of nickel-base alloys with the high-temperature properties of nickel strengthened by a dispersion of very small particles of thorium or yttrium oxide.

Mechanically alloyed nickel-20 weight-percent chromium alloys containing dispersed Y_2O_3 and/or La_2O_3 were compared with a commercial alloy and a mechanically alloyed material not containing rare-earth elements.[31] It was found that less than 0.1% La_2O_3 or Y_2O_3 improved the oxidation resistance of the nickel-chromium matrix compared with the commercial alloy. The rare-earth-doped alloys also exhibited better scale adhesion.

Crucibles made with yttrium oxide were found to successfully contain new titanium alloys with minimal interaction between the crucible and the molten titanium.[32] The crucibles, with compositions Y_2O_3-15%Ti and Y_2O_3 with a Y_2O_3-K_2SiO_3 face coat, resulted in typical casting contamination levels of 0.2%-0.49% oxygen and 0.2%-0.5% yttrium. These crucible materials could be used in the development of a low-cost-investment casting process for producing titanium alloys.

The use of the rare-earth ions Ho^{3+},

[21]Mari, A. New Metal Powder Stores Hydrogen for Energy Saving Applications. Am. Metal Market, v. 85, No. 101, May 25, 1977, p. 11.

[22]Chemical and Engineering News. Strides Made in Laser Fusion Research. V. 54, No. 13, March 1976, pp. 21-22.

[23]Energy and Mineral Resources Research Institute, Iowa State University (Ames, Iowa). Lawrence Livermore Laboratory Rare-Earth Laser Research, Rare-Earth Inf. Center News, v. 12, No.2, June 1, 1977, p. 1.

[24]Chemical and Engineering News. Powerful Laser Fusion Project Launched. V. 54, No. 11, Mar. 15, 1976, p. 7.

[25]Mid Atlantic Electronics. New Optical Electronic Material. V. 2, September-October 1976, p. 1.

[26]Industrial Research. 1976 I.R. 100 Award Winners. V. 18, No. 10, October 1976, pp. 32, 64-65.

[27]Gaston, C. (assigned to Société Francaise d'Electrométallurgie, Paris, France). Process for Treatment of Pyrochlore Concentrates. U.S. Pat. 3,947,542, Dec. 7, 1973.

[28]Gerstein, B. C., and D. B. Macaulay (assigned to Energy Research and Development Administration). Method of Removing Carbon Monoxide From Gases. U.S. Pat. 3,961,016, June 1, 1976.

[29]Energy and Mineral Resources Research Institute, Iowa State University (Ames, Iowa). Dynamite Application. Rare-Earth Inf. Center News, v. 11, No. 4, Dec. 1, 1976, p. 4.

[30]Benjamin, J. S. Mechanical Alloying. Sci. Am., v. 234, No. 5, May 1976, pp. 40-48.

[31]Michels, H. T. The Effect of Dispersed Reactive Metal Oxides on the Oxidation Resistance of Nickel -20 Wt Pct. Chromium Alloys. Met. Trans., v. 7A, No. 3, March 1976, pp. 379-388.

[32]Energy and Mineral Resources Research Institute, Iowa State University (Ames, Iowa). Yttria Molds Ti Alloys. Rare-Earth Inf. Center News, v. 12, No. 1, Mar. 1, 1977, p.4.

Er^{3+}, Tm^{3+}, and Yb^{3+} in anti-Stokes phosphors was studied.[33] Anti-Stokes phosphors, or up-converters, adsorb infrared photons and combine their energies in multiples of two or three to emit new photons in the visible or ultraviolet region. These anti-Stokes phosphors could be used for large area displays in place of conventional light-emitting diodes.

A psoriasis treatment using a dysprosium gas-discharge lamp was developed.[34] The treatment reportedly avoided the risk of toxic side effects sometimes associated with oral treatment.

Rare-earth research continued at Bureau of Mines metallurgy research laboratories on a number of projects: The use of rare-earth oxides as additives in high-temperature ceramics, determining optimum composition and conditions required to fabricate mischmetal-cobalt magnets, improving methods of production of rare-earth silicide, and the use of rare-earth transition metal catalysts for methanation of CO and H_2 during synthetic natural gas production and for liquid-phase catalytic reactions.

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[33]Garlick, G. F. J. Infrared to Visible Light Conversion. Contemporary Phys., v. 17, No. 2, 1976, pp. 379-388.

[34]Fischer, T., and J. Alsins (Dept. of Dermatology and Physical Chemistry, Uppsala Univ., Uppsala, Sweden). Treatment of Psoriasis With Trioxsalen Baths and Dysprosium Lamps. Acta Dermatovener (Stockholm), No. 56, 1976, pp. 383-390.

Rhenium

By Larry J. Alverson[1]

Domestic mine production of rhenium increased substantially in 1976, yet the industry was still operating 70% below full capacity level, or at about 80% of the average production level of the past several years. Consumption increased 38% over that of 1975 to a record 8,300 pounds. Imports of ammonium perrhenate also reached a record high of approximately 4,000 pounds, as prices for both metal powder and compounds continued to decline. Bimetallic platinum-rhenium catalysts used in petroleum refining continued to be the major use for rhenium, accounting for about 90% of consumption.

Table 1.—Salient rhenium statistics

(Pounds of contained rhenium)

	1972	1973	1974	1975	1976
Mine production[e]	6,100	7,000	5,000	2,000	4,400
Consumption[e]	4,800	4,400	4,500	6,000	8,300
Imports (metal and scrap)	168	1,437	40	59	82
Imports (ammonium perrhenate)	[e]1,921	[e]3,040	[e]3,287	[e]966	4,047
Stocks, Dec. 31[e]	13,000	20,000	24,000	21,000	21,200

[e]Estimate.

DOMESTIC PRODUCTION

Production of rhenium, as a byproduct of molybdenite (MoS_2) from various sources, increased in 1976 to 4,400 pounds contained in ammonium perrhenate (NH_4ReO_4) from 2,000 pounds in 1975. Shattuck Chemical Co., a subsidiary of Engelhard Minerals & Chemicals Corp., was the leading producer in the United States. Shattuck processed MoS_2 concentrate from the United States and Canada at its Denver, Colo., molybdenite roasting facility. Rhenium was recovered as ammonium perrhenate, from which the company made a variety of rhenium products.

M&R Refractory Metals, Inc., at its Winslow, N.J. plant, produced ammonium perrhenate for Engelhard Minerals & Chemicals Corp., and for Utah International, Inc. (UI) on a toll (contract) conversion basis. Production at the plant, halted by a fire in late 1975, was not resumed until the spring of 1976. In prior years, Molycorp, Inc., produced ammonium perrhenate from byproduct MoS_2 concentrate from western U.S. porphyry copper ores. However, in 1976 the rhenium production facility at Washington, Pa., was inactive. Kennecott Copper Corp.'s recovery operation at Garfield, Utah, remained closed during the year, although a subsidiary, Cleveland Refractory Metals, remained active in the domestic and international rhenium market, operating primarily from accumulated stocks.

The United States operated at about 30% of rhenium mine production capacity (byproduct) in 1976.

[1]Industry economist, Division of Ferrous Metals.

CONSUMPTION AND USES

Estimated 1976 consumption of rhenium was about 8,300 pounds, an increase of 38% from that of 1975. Increased usage took place in all sectors of the market, with the largest percentage increase in the flashbulb area. However, bimetallic platinum-rhenium catalysts used in petroleum refining represented about 90% of total rhenium consumption.

Of the three types of bimetallic catalytic reformers, semiregenerative units accounted for 49.4% of reforming capacity compared with 38.6% in 1975 and 27.6% in 1971. Cyclic and other bimetallic units combined, decreased in total capacity from that of 1975. However, the combined capacity of all three types was at an all-time high of over 60% of total U.S. reforming capacity, an increase of about 20% over that of 1975. Platinum-rhenium's share of total bimetallic catalyst capacity was about 65% to 75%, or about 40% to 45% of total domestic reforming capacity. Indications are that U.S. refiners are focusing on catalytic reforming and other octane improvement processes to cope with rising demand for unleaded gasoline and the tetraethyl lead gasoline phasedown.

The excellent activity and yield stability of Chevron Oil Co.'s platinum-rhenium catalysts reduce the necessity for more expensive cyclic or continuous reforming. The activity stability of these platinum-rhenium catalysts permits commercial, long-cycle, semiregenerative Rheniforming at a pressure of 125 pounds per square inch, gage. This operating pressure is as low as any achieved by other commercial cyclic and continuous reformers using bimetallic catalysts and is much lower than pressures used in cyclic reformers with monometallic platinum catalysts.

Numerous conversions to bimetallic reforming catalysts took place during the year; most were in the smaller refineries (2,000 to 8,000 barrels per stream-day).

The remaining 8% of estimated domestic rhenium consumption was used in X-ray tubes and targets, high-temperature thermocouples, electrical contacts, electronic devices, vacuum tube and flashbulb filaments, heating elements, metallic coatings, electromagnets, and high-temperature alloys in research and development work.

A new method for dating the universe was disclosed during the year; it is based on the decay of the radioactive isotope rhenium 187 to the stable isotope osmium 187. Use of this rhenium-osmium "clock" was proposed to be theoretically sounder than the other principal nuclear dating technique which is based on radioactive decay of uranium to thorium. One reason is that the half-life of rhenium-osmium decay, 44 billion years, is substantially longer than the generally accepted age of the universe. Therefore, calculations should be less susceptible to errors from uncertainties in details of the stellar processes involved than they would be using the shorter lived uranium-thorium decay process.[2]

The most widely used tungsten-rhenium (W-Re) thermocouple alloy combinations are W versus W-26% Re, W-5% Re versus W-26% Re, and W-3% Re versus W-25% Re. Because of the inherent brittleness of unalloyed tungsten, the W versus W-26% Re thermocouple wire is more difficult to handle than the other two. The average electromotive force of W-3% Re versus W-25% Re is slightly less than that of W vs W-26% Re and slightly more than that of W-5% Re versus W-26% Re. The ductility of W-3% Re is about equal to that of W-5% Re but much superior to that of unalloyed tungsten. All three combinations can be used to 2,760°C in hydrogen or inert gas atmospheres and in vacuum but undergo rapid deterioration under oxidizing conditions.

Research continued on rhenium's use in nickel-base high-temperature alloys. Rhenium was used in some cobalt-base alloys for high-temperature space applications and in some nickel-base alloys used in jet engine turbine blades. The cobalt-base alloy contains 2% rhenium, and the nickel-base alloy contains 0.5% rhenium.

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[2]Chemical& Engineering News. Method Dates Universe at 20 Billion Years. V. 54, No. 29, July 12, 1976, pp. 4-5.

PRICES

Prices paid for rhenium metal powder, perrhenic acid, and ammonium perrhenate during the year reportedly were below those quoted in most domestic trade journals. The price for metal powder ranged from $500 to $650 per pound, dependent upon grade and quantity. The prices for perrhenic acid and ammonium perrhenate, both of which are compounds of rhenium, ranged from less than $400 to more than $600 per pound. Some buyers paid prices outside these ranges, depending on their own situations. However, the general trend of prices continued downward, as it has in the past several years, reflecting the inactivity in new petroleum refinery construction.

Prices quoted by Cannon-Muskegon Corp., for W-Re thermocouple wire, ranging in size from .003 inch to .020 inch, were $3.50 to $21.00 per double foot of W versus W-26% Re. Prices for W-5% Re versus W-26% Re were $5.00 to $30.00 per double foot for similar sizes.

FOREIGN TRADE

Imports for consumption of ammonium perrhenate increased sharply during the year to a record high of 4,047 pounds of contained rhenium valued at $1,407,000. All the material came from Chile and West Germany. The Chilean material was withdrawn from bonded warehouses, while the West German material was directly imported. Imports increased partly in response to increased demand from nearly all sectors of the rhenium market.

Imports for consumption of rhenium metal and waste and scrap increased to 82 pounds from 59 pounds in 1975. This remains insignificant compared with the record high of 1,437 pounds in 1973. However, the disparity has been more than accounted for by increased ammonium perrhenate imports, which have a more favorable duty status and are more easily obtained.

The duty on imports of ammonium perrhenate from market economy countries was 4% ad valorem, while the duty on that from the central economy countries was 25% ad valorem. The import duty on rhenium metal from market economy countries remained at the January 1, 1972, rates of 5% ad valorem for unwrought rhenium metal and 9% ad valorem for wrought rhenium metal. Wrought metal items are, however, seldom imported to the United States. The duty on wrought and unwrought rhenium metal from central economy countries remained unchanged at 45% and 25% ad valorem, respectively. The rhenium content of imported molybdenite concentrate was not taxed. The duty on rhenium waste and scrap was suspended indefinitely in 1975.

Table 2.—U.S. imports for consumption of rhenium metal (including scrap), by country

(Gross weight, pounds)

Country	1972		1973		1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Austria	--	--	--	--	--	--	1	$300	--	--
Belgium-Luxembourg	--	--	110	$74,500	--	--	28	11,136	17	$8,687
France	25	$23,796	--	--	--	--	--	--	--	--
Germany, West	143	101,955	1,116	782,497	40	$27,734	30	15,760	65	29,060
Netherlands	--	--	211	147,679	--	--	--	--	--	--
Total	168	125,751	1,437	1,004,676	40	27,734	59	27,196	82	37,747

Table 3.—U.S. imports for consumption of ammonium perrhenate, by country[1]

(Rhenium content)

Country	1972		1973		1974		1975		1976	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Chile	76	$45	--	--	1,232	$449	--	--	1,280	$606
Germany, West	845	1,054	1,450	$1,913	1,520	1,185	401	$165	2,767	801
Sweden	1,000	1,189	1,590	1,916	535	171	565	277	--	--
Total	1,921	2,288	3,040	3,829	3,287	1,805	966	442	4,047	1,407

[1]Years 1972 through 1975 are estimated.

WORLD REVIEW

World production of rhenium totaled 14,200 pounds, compared with a total world potential capacity of 27,300 pounds, according to a report in the German trade journal Handelsblatt. Western European production reportedly was 3,300 pounds from a capacity of 5,700 pounds.

Porphyry copper deposits in Canada, Chile, Peru, and the United States were the major worldwide sources of rhenium. Rhenium recovery facilities outside the United States exist in Chile, Belgium, Bulgaria, East and West Germany, France, Sweden, the United Kingdom, and the U.S.S.R.

Canada.—All Canadian rhenium production was by UI's Island Copper mine on Vancouver Island, British Columbia. In 1976, shipments of molybdenite concentrate to the United States and Europe totaled about 2,400 tons containing approximately 4,500 pounds of rhenium. Companies in the United States and Europe toll-processed the MoS_2 concentrate for UI and returned the rhenium as ammonium perrhenate and perrhenic acid for subsequent sale. The mine has one of the richest concentrations of rhenium in the world.

Chile.—Production of rhenium in Chile in 1976 totaled 3,000 pounds contained in 4,350 pounds of ammonium perrhenate. Expansion of molybdenum output, and hence rhenium production capability, continued during the year. A new molybdenum plant at Saladillo was being built in 1976 to extract molybdenum from the Government-owned Andina copper mine's copper-molybdenum ore. The rhenium content averages 350 parts per million (ppm) in the molybdenite concentrate.

The firm Molibdenos y Metales, S.A. (MOLYMET) was created at the end of 1975. It will be responsible for producing and marketing molybdenum and rhenium products, which were formerly handled by Carburo y Metalurgia S.A. (Carbomet), a rhenium producer since 1971.

Germany, West.—Western Europe's newest petroleum refinery, near Wilhelmshaven, came onstream in December 1975. The refinery, owned by Mobil Oil AG, utilizes a catalytic reformer of Mobil design. It is a semiregenerative unit employing a platinum-rhenium catalyst, designed to operate under the most severe conditions for 6 months before regeneration. Several other bimetallic catalyst reforming units in Germany were scheduled for completion in 1977 and 1978. One such unit of Oberrheinische Mineralölwerke GmbH, located at Karlsruhe, will employ a 16,000 barrel-per-day (b/d) Platformer to make lead-free gasoline.

United Kingdom.—Small amounts of residues containing rhenium were recovered from roasting molybdenite concentrates by three companies: Murex, Ltd., at Reinham, Essex; High Speed Steel Alloys Ltd. at Widnes; and Minworth Metals Ltd., at Stowmarket. The residues were processed for rhenium recovery by Johnson Mathey and Co., and New Metals & Chemicals Ltd.

U.S.S.R.—The first Soviet rhenium recovery operation was put onstream in 1948 at the Balkhash plant in Kazakhstan. Rhenium was recovered from solutions derived from liquors used to leach low-grade molybdenite concentrate. The liquors were upgraded by evaporation, and metal was recovered from solution by cementation with metallic iron. Presently, the same plant treats flue dusts of copper, lead, and zinc smelters as well as solutions from molybdenite leaching. The plant employs up-to-date technology for the recovery of rhenium.

Since porphyry copper deposits are not abundant in the USSR, the Soviets rely on a number of sources for rhenium supply. Therefore, a number of processes that recover rhenium from flue dust of various nonferrous metal smelters as well as from molybdenite concentrate have been developed. The dusts average between 200 and 700 ppm rhenium and require hydrometallurgical treatment to recover the rhenium.

One source of rhenium is the Dzhezkazgan porphyry copper mine where the rhenium concentration ranges from 10 to 100 ppm. It is highest in the bornite mineralization and falls to about 40 ppm in chalcopyrite and sphalerite mineralization. Galena mineralization contains about 20 ppm rhenium. The oxidized cap contains only 0.04 ppm rhenium.[3]

TECHNOLOGY

The Bureau of Mines demonstrated an electrooxidation-solvent extraction-carbon adsorption process for recovering molybdenum and rhenium from low-grade molybdenite concentrate at a commercial operation. The equipment used was a prototype of a commercial size, 125-kilovoltampere, 41-electrode cell operating at 1,000 amperes. The flow sequence consisted of dissolution of metal values by electrooxidation, liquid-solid separation by thickening and filtering, acidification, and chlorate ion removal by sulfur dioxide treatment. This was followed by concentration of molybdenum and rhenium by solvent extraction, separation of molybdenum and rhenium by carbon adsorption, and metal value recovery by crystallization. The rhenium was recovered as ammonium perrhenate. The electrooxidation process in the pilot plant resulted in dissolution of 99.1% of the rhenium with an energy consumption of 13.7 kilowatt-hours per pound of molybdenum extracted.[4]

The Bureau published results of a study on the thermodynamic properties of high-purity rhenium oxides. Prior to this investigation, high-temperature enthalpy or Gibbs energy of formation data were not available for the three stable oxides of rhenium - ReO_2(s), ReO_3(s), and Re_2O_7(s,l). The temperature range of the heat capacity measurements was 5° to 310°K for ReO_2, and 8° to 309°K for ReO_3. High-temperature enthalpy measurements alone were determined for pure Re_2O_7(s,l).[5]

Activated sintering was shown by Soviet scientists in 1976 to be synonymous with "activated alloying" as applied to the powder metallurgy of molybdenum- and tungsten-base alloys. Thus, the use of small additions of palladium or nickel to powder mixtures of tungsten and rhenium or tungsten and chromium effectively promoted alloying during sintering for 1 to 2 hours at 1200° to 1250° C.

A patent was issued for the recovery of rhenium from molybdenite or copper sulfide ore roaster gases. Dust-free roaster gas was wet-filtered, and the rhenium-bearing liquor was recycled to upgrade the rhenium concentration. The rhenium-bearing liquor from the first scrubbing step was added to the second scrubbing step, and the excess accumulated liquor was drawn off for conventional processing for extraction of the rhenium values.[6]

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[3]Sutulov, A. Molybdenum and Rhenium, 1778-1977. University of Concepción, Concepción, Chile, 1976, pp. 224.

[4]Scheiner, B. J., R. E. Lindstrom, and D. L. Pool. Extraction and Recovery of Molybdenum and Rhenium From Molybdenite Concentrates by Electrooxidation: Process Demonstration. BuMines RI 8145, 1976, 12 pp.

[5]Stuve, J. M., and M. J. Ferrante. Thermodynamic Properties of Rhenium Oxides, 8 to 1,400 K. BuMines RI 8199, 1976, 15 pp.

[6]Hevia, R. J., and L. Soto-Krebs. Recovery of Rhenium From Gases Produced in the Roasting of Molybdenite or Copper Sulfide Ore. Canadian Pat. 986,722, Apr. 6, 1976.

Salt

By Russell J. Foster[1]

Salt production in the United States rose 5% in 1976 to 43,801,000 tons. The amount of salt sold or used by domestic producers was up 8%, mostly owing to greater chlorine-caustic soda production and increased use of salt on highways. Solar, rock, and brine salt exhibited the most substantial gains. Prices of all forms of salt advanced. The largest price increases occurred in evaporated salt. Imports reached a record 4.4 million tons.

Legislation and Government Programs.—The Energy Policy and Conservation Act of 1975 authorized the creation of a strategic petroleum reserve consistent with a plan developed by the Federal Energy Administration (FEA). In 1976 FEA submitted for Congressional approval a plan that called for the storage of 500 million barrels of crude oil by December 1982 in underground salt domes, salt mines, or rock caverns, which are readily accessible to tankers or major crude oil pipelines, or both. Capacity for storing approximately 240 million barrels will be developed for an early storage reserve, and FEA will endeavor to fill this capacity to 150 million barrels by December 1978. The reserve will cost $7.5 to $8.0 billion to design, construct, fill, and maintain through 1982. Underground storage will minimize cost and environmental problems while maximizing security. Existing caverns are available and new ones can be formed efficiently. Six of eight candidate sites for storage of the reserve are salt deposits in Louisiana and Texas. Rock salt has several characteristics that make it attractive for cavern construction and storage. When relatively pure, it is generally impervious to liquid and gas, has high compression strength, exhibits plasticity to seal incipient fractures, and can easily be solution-mined. The feasibility of using salt caverns for storage has been previously demonstrated in Europe and the United States.[2]

Returning to its original position, the Federal Government announced plans to dispose of radioactive wastes by storing them in stable geologic formations, such as salt deposits, under the continental United States. The Energy Research and Development Administration proposed to construct

[1]Physical scientist, Division of Nonmetallic Minerals.
[2]Federal Energy Administration. Strategic Petroleum Reserve. The Plan in Brief. December 1976, 23 pp.

Table 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Production[1]	44,010	44,298	46,423	41,710	43,801
Sold or used by producers[1]	45,022	43,910	46,536	41,030	44,191
Value	$296,772	$306,103	$360,763	$368,063	$430,959
Exports	869	609	521	1,332	1,007
Value	$5,544	$4,400	$4,276	$9,070	$10,326
Imports for consumption	3,463	3,207	3,358	3,215	4,352
Value	$11,979	$12,554	$14,428	$15,272	$23,476
Consumption, apparent	47,616	46,508	49,373	42,913	47,536
World: Production	161,350	170,483	r183,236	r178,432	183,252

rRevised.
[1]Excluding Puerto Rico: 29,000 short tons (1972-74), and an estimated 27,000 short tons (1975-76).

a waste isolation pilot plant in the bedded salt and potash of southeastern New Mexico. The main purpose of the facility would be to test and demonstrate the operational and technical principles of a permanent repository.[3]

DOMESTIC PRODUCTION

The amount of salt sold or used by domestic producers increased nearly 8% in 1976. Solar salt showed the largest gain, 11%. Rock salt and salt in brine were also up significantly. In 1976, 55 salt-producing companies operated 99 plants in 16 States and Puerto Rico. Twelve of the companies produced over 1 million tons each, accounting for 87% of U.S. salt production. The five leading States in the amount of salt sold or used follow:

State	Percent of total
Louisiana	30
Texas	22
New York	15
Ohio	11
Michigan	10
Total	88

The percentage of salt sold or used by domestic producers in 1976 by type follow:

	Percent
Salt in brine	52
Mined rock salt	35
Vacuum-pan salt	8
Solar-evaporated salt	4
Grainer or open-pan salt	1

The water in the Great Salt Lake continued to rise in 1976, reaching its highest level in 50 years. To prevent further damage to dikes around salt operations and other lakeshore industries, the Great Salt Lake Division of Utah's Department of Natural Resources was considering a proposal to pump a large amount of the water to a nearby desert area, creating a new lake.[4]

The final phase of 9 years of litigation concluded in June 1976, when the U.S. Supreme Court ruled that Utah also held title to all relict shorelands of the Great Salt Lake, thus granting total ownership of the lake and its mineral content to the State. The shorelands had been covered by water at the time of Utah's statehood, but became exposed when the shorelines receded. Morton Salt Co. had been the largest single private landowner of lakeshore prior to the decision.[5]

In March 1976, Morton Salt Co. announced the closing of its salt mine at Seneca Lake, N.Y., owing to high operating costs and an oversupply of rock salt in the market area.[6] Cargill, Inc., acquired majority ownership in Watkins Salt Co., an evaporated salt producer located at Watkins Glen, N.Y.[7]

STOCKS

Total salt stocks at yearend 1976 as reported by producers amounted to 2.3 million tons, or 5% of production. Over 56% was in the form of rock salt and 35% was solar salt. Solar salt had the greatest share of its production in stocks, 46%. Rock salt stocks were 8% of production, and the amounts of open-pan and vacuum-pan salt production in stocks were 3% and 2%, respectively. Brine inventory at yearend was small.

[3]Chemical and Engineering News. Nuclear Wastes to Be Stored Underground. V. 54, No. 21, May 17, 1976, p. 7.
Wall Street Journal. Government Ponders How to Safely Dump Toxic Nuclear Waste. V. 188, No. 17, July 26, 1976, pp. 1, 19.
[4]Engineering and Mining Journal. Utah Seeks Solution to Great Salt Lake Water Level. V. 177, No. 8, August 1976, p. 30.
Chemical Week. Brine Users Need More Than a Pinch of Salt. V. 118, No. 26, June 30, 1976, p. 29.
[5]Engineering and Mining Journal. In the U.S. Utah. V. 177, No. 8, August 1976, p. 131.
Bauman, J. State May Net Billions From Lake. Deseret News, July 12, 1976, p. B-1.
[6]Wall Street Journal. Morton-Norwich to Post Net Loss in June 30 Year. V. 187, No. 56, Mar. 22, 1976, p. 10.
[7]Cargill, Inc. News Release. Dec. 29, 1976.

CONSUMPTION AND USES

A resurgent U.S. chemical industry increased its consumption of salt in 1976. The amount of salt sold or used by domestic producers for the production of chlorine-caustic soda rose 2 million tons. Synthetic soda ash production consumed less salt because of reduced capacity, but salt usage in the syntheses of other chemicals was up. Nearly 59% of all salt sold or used by domestic producers was raw material for the manufacture of chemicals.

Weather conditions across the nation necessitated a large increase in the use of salt on highways. Most other categories of distribution also showed gains over 1975, particularly the textile, metals, oil, and pulp and paper industries. The only area besides soda ash production in which salt consumption dropped notably was the rubber industry.

Table 2.—Salt sold or used by producers in the United States,[1] by method of recovery

(Thousand short tons and thousand dollars)

Recovery method	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Evaporated:				
Bulk:				
Open pans or grainers	526	22,626	536	27,694
Vacuum pans	2,801	120,465	2,908	147,037
Solar	1,583	19,009	1,752	25,156
Pressed blocks	436	17,808	412	18,401
Total[2]	5,345	179,908	5,607	218,288
Rock:				
Bulk	14,200	104,179	15,592	121,875
Pressed blocks	84	3,733	76	3,807
Total[2]	14,283	107,912	15,668	125,682
Salt in brine (sold or used as such)	21,401	80,243	22,917	86,989
Grand total[2]	41,030	368,063	44,191	430,959

[1]Excludes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—Salt sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Kansas[1]	1,446	31,214	1,310	35,291
Louisiana	12,166	77,116	13,491	91,952
Michigan	4,020	68,353	4,219	79,740
New Mexico	147	1,048	W	W
New York	5,978	57,344	6,495	66,441
Ohio	5,083	54,651	5,052	66,332
Texas	8,560	42,119	9,718	48,875
Utah	631	7,717	705	10,090
West Virginia	972	4,671	1,118	W
Other States[2]	2,026	23,830	2,083	32,239
Total[3]	41,030	368,063	44,191	430,959
Puerto Rico[e]	27	639	27	639

[e]Estimate.
W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Quantity and value of brine included with "Other States."
[2]Includes Alabama, Arizona, California, Colorado, Kansas (brine only), Nevada, North Dakota, Oklahoma, and items indicated by symbol W.
[3]Data may not add to totals shown because of independent rounding.

Table 4.—Evaporated salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1975		1976	
	Quantity	Value	Quantity	Value
Kansas	771	26,274	785	30,795
Louisiana	275	15,112	297	19,014
Michigan	1,185	50,351	1,190	60,641
New York	579	24,595	617	29,780
Utah	590	7,508	673	9,848
Other States[1]	1,945	56,067	2,046	68,210
Total [2]	5,345	179,908	5,607	218,288
Puerto Rico[e]	27	639	27	639

[e]Estimate.
[1]Includes Arizona, California, Nevada, New Mexico, North Dakota, Ohio, Oklahoma, and Texas.
[2]Data may not add to totals shown because of independent rounding.

Table 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1972	14,434	91,041
1973	12,347	78,544
1974	14,835	108,692
1975	14,283	107,912
1976	15,668	125,682

Table 6.—Pressed-salt blocks sold by original producers of salt in the United States

(Thousand short tons and thousand dollars)

Year	From evaporated salt		From rock salt		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1972	376	10,927	66	2,138	442	13,065
1973	451	14,508	72	2,551	523	17,059
1974	440	15,888	82	3,308	522	19,196
1975	436	17,808	84	3,733	520	21,541
1976	412	18,401	76	3,807	[1]487	22,208

[1]Data do not add to total shown because of independent rounding.

Table 7.—Distribution of salt sold or used by producers in the United States, by use

(Thousand short tons)

Consumer or use	1975				1976			
	Evaporated	Rock	Brine	Total[1]	Evaporated	Rock	Brine	Total[1]
Chlorine	234	2,211	16,508	18,952	280	2,256	18,411	20,947
Soda ash	([2])	([2])	4,492	4,492	W	W	4,060	4,061
All other chemicals	W	553	W	1,021	W	623	W	1,158
Textile and dyeing	109	W	W	180	130	73	--	204
Meatpackers, tanners, and casing manufacturers	241	338	--	579	246	332	--	578
Dairy	63	5	--	68	68	6	--	74
Canning	165	W	W	259	161	96	([2])	257
Baking	W	W	--	125	W	W	--	126
Flour processors (including cereal)	79	21	([2])	101	77	21	([2])	98
Other food processing	572	W	W	611	602	33	([2])	635
Feed dealers	858	452	--	1,310	893	439	--	1,332
Feed mixers	270	283	--	552	296	296	([2])	593
Metals	W	229	W	265	39	303	([2])	342
Rubber	W	11	W	127	W	9	W	108
Oil	75	81	105	261	92	89	132	312
Paper and pulp	W	113	W	172	W	148	W	213

See footnotes at end of table.

Table 7.—Distribution of salt sold or used by producers in the United States, by use —Continued

(Thousand short tons)

Consumer or use	1975 Evaporated	1975 Rock	1975 Brine	1975 Total[1]	1976 Evaporated	1976 Rock	1976 Brine	1976 Total[1]
Water softener manufacturers and service companies	282	W	W	586	294	W	W	580
Grocery stores	786	205	--	991	784	214	--	998
Highway use	W	7,439	W	7,680	W	8,707	W	8,930
U.S. Government	24	95	(2)	119	27	47	(2)	74
Distributors (brokers, wholesalers, etc.)	255	552	--	807	328	576	--	904
Miscellaneous[3]	1,391	1,482	601	[4]1,924	1,333	1,365	548	[4]1,910
Total[1]	[5]5,403	[5]14,071	[5]21,706	[6]41,180	[5]5,651	[5]15,633	[5]23,151	[6]44,435

W Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous."
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit; included with "Miscellaneous."
[3]Includes withheld figures and some exports and consumption in overseas areas administered by the United States.
[4]Incomplete totals; withheld totals are included with total for each specific use.
[5]Differs from totals shown in tables 2, 4, and 5 because of changes in inventory.
[6]Differs from totals shown in tables 1, 2, and 3 because of changes in inventory.

Table 8.—Distribution (shipments) of evaporated and rock salt in the United States, by destination

(Thousand short tons)

Destination	1975 Evaporated Domestic	1975 Evaporated Imported	1975 Rock Domestic	1975 Rock Imported	1976 Evaporated Domestic	1976 Evaporated Imported	1976 Rock Domestic	1976 Rock Imported
Alabama	51	--	388	--	50	--	457	(1)
Alaska	W	--	--	--	W	--	--	--
Arizona	34	7	4	--	W	W	W	--
Arkansas	24	--	81	--	25	--	99	--
California	881	141	W	(1)	947	W	W	--
Colorado	135	--	25	--	151	--	W	--
Connecticut	15	W	W	(1)	17	W	W	(1)
Delaware	5	5	133	W	5	16	W	--
District of Columbia	W	(1)	W	W	2	W	W	--
Florida	56	(1)	145	--	58	W	136	--
Georgia	60	--	229	--	66	W	242	(1)
Hawaii	W	(1)	--	--	W	(1)	--	--
Idaho	62	--	3	--	59	--	W	--
Illinois	358	W	1,051	W	364	(1)	1,059	W
Indiana	149	1	532	38	153	(1)	640	W
Iowa	177	(1)	389	W	181	(1)	276	(1)
Kansas	101	--	228	--	100	--	196	--
Kentucky	47	W	465	(1)	43	(1)	576	(1)
Louisiana	49	--	436	--	54	--	W	--
Maine	9	W	W	W	9	(1)	W	W
Maryland	47	111	57	W	38	61	W	(1)
Massachusetts	37	W	495	W	39	W	428	W
Michigan	198	(1)	W	430	191	(1)	W	569
Minnesota	153	(1)	415	W	168	W	326	W
Mississippi	23	--	95	--	23	--	110	--
Missouri	108	--	317	--	110	--	345	--
Montana	59	--	1	--	56	--	2	--
Nebraska	110	--	104	--	107	--	85	--
Nevada	40	1	W	--	52	W	W	--
New Hampshire	W	(1)	154	W	W	(1)	W	W
New Jersey	122	W	472	W	135	118	608	(1)
New Mexico	27	--	66	--	51	--	27	W
New York	295	38	1,571	W	305	74	1,898	W
North Carolina	94	(1)	133	(1)	114	W	W	(1)
North Dakota	W	--	7	(1)	W	--	6	(1)
Ohio	353	1	1,261	W	368	--	1,687	W
Oklahoma	45	--	67	--	50	--	67	--
Oregon	25	192	(1)	--	48	W	W	--
Pennsylvania	169	69	956	W	176	68	1,116	W
Rhode Island	W	W	W	W	12	W	W	--
South Carolina	43	--	13	--	49	--	15	(1)
South Dakota	60	--	45	--	60	--	34	--

See footnotes at end of table.

Table 8.—Distribution (shipments) of evaporated and rock salt in the United States, by destination —Continued

(Thousand short tons)

Destination	1975				1976			
	Evaporated		Rock		Evaporated		Rock	
	Domestic	Imported	Domestic	Imported	Domestic	Imported	Domestic	Imported
Tennessee	120	(1)	W	(1)	118	--	656	(1)
Texas	152	--	394	--	204	--	277	--
Utah	175	--	W	--	195	--	W	--
Vermont	5	(1)	166	--	W	(1)	242	(1)
Virginia	80	14	130	(1)	89	49	131	(1)
Washington	60	610	(1)	--	65	707	(1)	--
West Virginia	19	W	180	(1)	20	W	243	(1)
Wisconsin	185	W	576	W	192	W	547	W
Wyoming	31	--	W	--	35	--	W	--
Other [2]	352	188	2,286	620	298	539	3,102	822
Total [3]	[4]5,403	[5]1,378	[4]14,071	[5]1,088	[4]5,651	[5]1,632	[4]15,633	[5]1,391

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1]Less than 1/2 unit.
[2]Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, some shipments to unspecified destinations, and States indicated by symbol W.
[3]Data may not add to totals shown because of independent rounding.
[4]Differs from totals in tables 2, 4, and 5 because of changes in inventory.
[5]Differs from totals in tables 1, 11, 12, and 13 because of incomplete data on the distribution of imported salt.

PRICES

The following salt prices were quoted at yearend 1976 in Chemical Marketing Reporter:[8]

	Per 100 pounds
Salt, evaporated, common, 100-pound bags, carlots or trucklots, works	$1.99
Salt, chemical-grade, same basis	2.23
Salt, rock, medium coarse, same basis	1.35
Salt, rock, extra coarse, same basis	1.40

The average values of different classes of salt in bulk, f.o.b. works, as reported by producers follow:

	Per ton	
	1975	1976
Evaporated:		
Open pans or grainers	$43.02	$51.67
Vacuum pans	43.01	50.56
Solar	12.01	14.36
Pressed blocks, all sources	41.42	45.51
Rock salt, bulk	7.34	7.82
Salt in brine	3.75	3.80

The weighted average price increase for all salt was 5%. Open-pan salt displayed the largest rise in price, 20%. The smallest increase occurred in brine at slightly more than 1%.

In October 1976 four major salt companies, Cargill Inc., Diamond Crystal Salt Co., International Salt Co., and Morton Salt Co., announced price increases ranging from 8% to 12% for rock and evaporated salt, effective in late 1976 and early 1977. Increased costs of energy, labor, packaging, and distribution were the factors cited.[9]

[8]Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 210, No. 26, Dec. 27, 1976, p. 39.

[9]Wall Street Journal. Two More Processors Set Price Increases on Salt of at Least 8%. V. 188, No. 82, Oct. 26, 1976, p. 40.

FOREIGN TRADE

In 1976 exports of salt from the United States declined 24%, to 1 million tons. Canada received 95% of exported U.S. salt.

The United States imported a record 4.4 million tons of salt, an increase of 35%. Canada regained its position as the principal foreign source of salt for the United States with 38% of the total. The Bahamas provided 32% and Mexico 16% of salt imports. Net imports of salt claimed 7% of apparent consumption.

Table 9.—Salt shipped to the Commonwealth of Puerto Rico and overseas areas administered by the United States

Area	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
American Samoa	210	$17	[1]213	[1]$11
Puerto Rico	19,375	2,261	17,106	2,197
Virgin Islands	[2]219	26	398	22

[1]Effective August 1976, data on shipments from the United States to American Samoa were no longer compiled by the Bureau of the Census owing to elimination of the requirement for filing export declarations for such shipments. The 1976 figure, therefore, reflects only the months January through July.
[2]Adjusted by the Bureau of Mines.

Table 10.—U.S. exports of salt, by country

(Thousand short tons and thousand dollars)

Destination	1975		1976	
	Quantity	Value	Quantity	Value
Australia	(1)	11	1	9
Bahamas	2	117	2	137
Belgium-Luxembourg	(1)	4	(1)	14
Canada	1,315	7,584	958	7,918
Costa Rica	1	34	1	60
Denmark	(1)	23	(1)	29
France	(1)	25	(1)	3
Haiti	(1)	20	(1)	25
Honduras	(1)	17	(1)	10
Jamaica	(1)	9	1	29
Japan	(1)	33	(1)	23
Kuwait	(1)	26	(1)	40
Mexico	3	189	12	287
Netherlands Antilles	1	93	1	133
New Zealand	1	63	1	47
Panama	1	24	(1)	49
Peru	(1)	7	(1)	8
Philippines	1	11	(1)	3
Saudi Arabia	1	206	5	863
South Africa, Republic of	(1)	10	--	--
Sweden	(1)	22	(1)	20
Trinidad and Tobago	2	176	(1)	17
Trust Territory of the Pacific Islands	(1)	28	(1)	14
United Arab Emirates	1	102	3	279
United Kingdom	(1)	63	20	73
Other	3	173	2	236
Total	1,332	9,070	1,007	10,326

[1]Less than 1/2 unit.

Table 11.—U.S. imports for consumption of salt, by country

(Thousand short tons and thousand dollars)

Country	1975		1976	
	Quantity	Value	Quantity	Value
Bahamas	1,141	5,054	1,397	6,295
Canada	[1]873	[1]4,713	1,654	9,980
Chile	28	139	146	667
Germany, West	(2)	120	1	144
Mexico	1,042	4,554	686	4,139
Netherlands	[3]8	[3]36	(2)	(2)
Netherlands Antilles	123	596	151	802
Norway	--	--	20	117
Spain	--	--	252	1,134
United Kingdom	(2)	1	24	68
Other	[4](2)	[r]59	[5]21	[5]130
Total	3,215	15,272	4,352	23,476

[r]Revised.
[1]Includes salt brine through San Francisco customs district, 12 short tons ($449).
[2]Less than 1/2 unit.
[3]Includes salt brine through Baltimore customs district, 11 short tons ($720).
[4]Includes salt brine from Denmark through Cleveland customs district, 3 short tons ($2,247).
[5]Includes salt brine from Denmark through Cleveland customs district, 10 short tons ($10,829); from Japan through Chicago customs district, 11 short tons ($730).

Table 12.—U.S. imports for consumption of salt, by class

(Thousand short tons and thousand dollars)

Year	In bags, sacks, barrels or other packages (dutiable)		Bulk (dutiable)	
	Quantity	Value	Quantity	Value
1974	28	746	[1]3,330	[1]13,682
1975	10	580	[2]3,205	[2]14,692
1976	19	691	[3]4,333	[3]22,774

[1]Includes salt brine from West Germany through Baltimore customs district, 8,800 short tons ($4,926).
[2]Includes salt brine from Canada through San Francisco customs district, 12 short tons ($449); from Denmark through Cleveland customs district, 3 short tons ($2,247); from the Netherlands through Baltimore customs district, 11 short tons ($720).
[3]Includes salt brine from Denmark through Cleveland customs district, 10 short tons ($10,829); from Japan through Chicago customs district, 11 short tons ($730).

Table 13.—U.S. imports for consumption of salt, by customs district

(Thousand short tons and thousand dollars)

Customs district	1975		1976	
	Quantity	Value	Quantity	Value
Baltimore, Md	197	886	240	1,087
Boston, Mass	204	914	261	1,101
Buffalo, N.Y	64	316	51	281
Chicago, Ill	32	118	155	905
Cleveland, Ohio	65	321	64	374
Detroit, Mich	312	1,736	861	4,964
Duluth, Minn	120	621	162	1,106
Houston, Tex	(1)	104	(1)	126
Los Angeles, Calif	173	757	145	696
Milwaukee, Wis	234	1,205	340	2,073
New Orleans, La	10	84	9	70
New York City	234	1,202	182	1,055
Norfolk, Va	--	--	25	124
Ogdensburg, N.Y	24	120	14	81
Philadelphia, Pa	(1)	3	(1)	2
Portland, Me	193	906	287	1,431
Portland, Oreg	432	1,957	411	2,216
Providence, R.I	23	116	49	197
St. Albans, Vt	2	108	3	113

See footnotes at end of table.

Table 13.—U.S. imports for consumption of salt, by customs district —Continued

(Thousand short tons and thousand dollars)

Customs district	1975		1976	
	Quantity	Value	Quantity	Value
San Juan, P.R	185	746	315	1,261
Savannah, Ga	209	866	260	1,093
Seattle, Wash	428	1,847	498	3,000
Tampa, Fla	33	133	--	--
Wilmington, N.C	41	203	20	117
Other	(1)	3	(1)	3
Total	3,215	15,272	4,352	23,476

[1]Less than 1/2 unit.

Table 14.—U.S. imports for consumption of salt, by use as reported by salt producers

(Thousand short tons)

Use	1975	1976
Government (highway use)	1,160	1,263
Chemical industry	710	962
Water-conditioning service companies	319	140
Other	277	659
Total[1]	2,466	3,024

[1]Disagreement with totals in tables 1, 11, 12, and 13 is because of incomplete data on the uses of imported salt.

WORLD REVIEW

World salt production in 1976 was estimated at 183 million tons. Distribution of the production by continent follows:

	Million tons	Percent
Europe	66.9	37
North America	57.6	31
Asia	44.8	25
Oceania	5.9	3
South America	5.9	3
Africa	2.2	1

The 12 principal salt-producing nations, which together accounted for 81% of the world's salt, are as follows:

	Percent
United States	24
People's Republic of China	18
U.S.S.R.	8
United Kingdom	5
Germany, West	4
France	4
Poland	3
Australia	3
Canada	3
Mexico	3
India	3
Romania	3

Algeria.—A contract was awarded to Tecnosel of Milan, Italy, for a technical and economic feasibility study of a 500,000-ton-per-year solar salt operation.[10]

[10]European Chemical News. Tecnosel Wins Algerian Solar Salt Study. V. 29, No. 761, Nov. 12, 1976, p. 48.

Australia.—In March, following Japanese acceptance of a 40% increase in the price of Mexican salt, the Australian Government raised the minimum price for salt exports to Japan by 33%. An interim increase of 24% had been agreed upon at the beginning of 1976.[11]

Canada.—Soquem, the crown-owned Quebec mining exploration company, announced plans to produce 1 million tons of salt per year by 1980 from deposits on the Magdalen Islands in the Gulf of St. Lawrence. In addition to mine development work, construction of a $20 million port for shipping the salt to the mainland was scheduled. Initially, total salt production has been designated for deicing the roads of Quebec.[12]

International Minerals & Chemical Corp. (Canada) Ltd. signed an agreement with the Government of New Brunswick to explore and develop a potash and salt prospect in a 77-square-mile area near Salt Springs. The initial exploration work could lead to development of a mine and plant by 1982, in which case the agreement would commit the company to produce and market a minimum tonnage within a specified time and to pay provincial royalties on the products.[13]

Germany, West.—Salzgewinnungsgesellschaft of Westfalen began drilling for brine in the Gronau area near the German-Dutch border. Plans call for the drilling of 15 new holes by 1978. The brine will be pumped through a pipeline to electrolysis plants at Rheinberg and Marl.[14]

Greece.—Bertzeletos & Bros. and the Dutch firm Akzo Zout Chemie Nederland BV have formed a joint venture called Greek Salt for the purification, drying, and packaging of solar salt. The new facility, near Soussaki on the Gulf of Corinth, was scheduled to go onstream in October 1976 with a production of 24,000 tons per year[15]

Hellenic Industrial and Mining Investment Co. was investigating the possible expansion and modernization of the solar salt works at Messolonghi in western Greece. An increase in capacity from the present 110,000 tons to 550,000 tons would cover the requirements of a proposed chlorine-caustic soda plant near Kavala, and a soda ash facility at Messolonghi.[16]

Iran.—The construction of a $10 million salt operation with a production capacity of 550,000 tons per year was completed near Bandar Shahpur. About 80% of the salt was slated for use in chlorine-caustic soda plants of a planned petrochemical complex. The remaining salt was designated for sale within Iran.[17]

Italy.—Montedison and the Sicilian Mining Board, which runs all the rock salt mines in Sicily through a subsidiary, have established Soc. Salitaliana to coordinate mining from all sources and improve the efficiency of domestic and foreign rock salt marketing. Montedison has a 990,000-ton-per-year salt operation at Ciro Marina.[18]

Libya.—A West German group headed by Salzgitter Industriebau announced plans to construct a $540 million petrochemical complex for the Libyan Government at Abu Kammash. The principal unit, scheduled to go onstream in 1980, will utilize Libyan salt in a polyvinyl chloride plant.[19]

Mexico.—The Mexican Government announced its intention to increase its 25% share to a majority holding in Exportadora de Sal, the salt-mining complex 75% owned by Mitsubishi of Japan. The Government's effort to obtain more control over its raw material resources followed a long-running dispute with Japan over salt prices, which culminated in the temporary suspension of Mitsubishi's salt-mining activities in 1975. Most of the production of the Baja California mine has been exported to Japan and the United States. Nationalization of the salt operation, coupled with a projected increase in production to 7.7 million tons per year, was intended to place more emphasis on domestic consumption.[20]

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[11]Chemical Age. Australia Fixes Salt Price. V. 112, No. 2959, Apr. 2, 1976, p. 8.

[12]Engineering and Mining Journal. In Canada. Quebec. V. 177, No. 9, September 1976, p. 287.
Industrial Minerals. Salt/Potash Show Promise. No. 111, December 1976, p. 10.

[13]Chemical Marketing Reporter. Potash Pact Is Signed by IMC and Canadians. V. 209, No. 4, Jan. 26, 1976, p. 3.

[14]Industrial Minerals. Company News and Mineral Notes. No. 109, October 1976, p. 56.

[15]———. Dutch-Greek Salt Venture. No. 111, December 1976, p. 13.

[16]Chemical Engineering. CPI News Briefs. V. 83, No. 19, Sept. 13, 1976, p. 116.
Page 58 of work cited in footnote 15.

[17]Industrial Minerals. Company News and Mineral Notes. No. 101, February 1976, p. 50.
Chemical Age. Massive Salt Farm in Iran Will Supply Caustic Soda Plant. V. 112, No. 2953, Feb. 20, 1976, p. 8.

[18]Mining Annual Review. June 1977, p. 525.

[19]Chemical Week. Libya Slates New Complex. V. 119, No. 10, Sept. 8, 1976, p. 49.

[20]Industrial Minerals. Salt Nationalized. No. 107, August 1976, pp. 10, 11.
Chemical Age. Mexico to Take Control of Mitsubishi Salt Mine. V. 112, No. 2969, June 11, 1976, p. 11.

Table 15.—Salt: World production, by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
North America:			
Bahamas	1,132	1,359	1,644
Canada	6,004	5,683	5,750
Costa Rica	15	17	22
Dominican Republic[e]	44	44	44
El Salvador	29	25	[e]25
Guatemala	10	[e]10	[e]12
Honduras	[e]35	34	[e]34
Martinique[e]	180	180	180
Mexico	[r]6,071	5,902	5,061
Netherlands Antilles[e]	530	530	530
Nicaragua	11	13	16
Panama	25	13	14
United States, including Puerto Rico:			
Rock salt	14,835	14,283	15,668
Other salt:			
United States	31,701	26,747	28,523
Puerto Rico	29	[e]27	[e]27
South America:			
Argentina	1,054	1,268	[e]1,323
Brazil	1,711	2,365	[e]2,425
Chile	[r]264	330	472
Colombia:			
Rock salt	203	204	[e]207
Other salt	761	817	[e]778
Peru[e]	327	390	335
Venezuela	246	320	[e]331
Europe:			
Albania[e]	55	55	55
Austria:			
Rock salt	(2)	1	1
Other salt	[r]598	509	634
Bulgaria	143	98	[e]110
Czechoslovakia	[r]251	[e]250	[e]250
Denmark	466	269	385
France:			
Rock salt and brine salt	5,723	4,862	5,495
Marine salt	1,190	1,242	1,577
Germany, East	2,577	2,677	[e]2,646
Germany, West (marketable):			
Rock salt	7,697	5,929	7,363
Marine salt and other	4,782	4,340	899
Greece	75	63	154
Italy:			
Rock salt and brine salt	4,416	3,518	3,759
Marine salt	979	1,345	664
Malta	[r e]2	[r e]2	(2)
Netherlands	3,734	2,965	3,336
Poland:			
Rock salt	1,549	1,744	1,821
Other salt	[r]3,622	3,885	4,209
Portugal:			
Rock salt	[r]341	325	334
Marine salt	246	234	[e]243
Romania	4,324	4,223	4,641
Spain:			
Rock salt[3]	1,791	2,021	[e]2,094
Marine salt and other evaporated[4]	697	1,431	[e]1,433
Switzerland	[r]330	261	343
U.S.S.R.[e]	[r]14,771	[r]15,102	15,432
United Kingdom:			
Rock salt	1,091	992	[e]992
Other salt	8,191	7,579	7,716
Yugoslavia:			
Rock salt	103	86	[e]76
Other salt	249	239	[e]243

See footnotes at end of table.

Table 15.—Salt: World production, by country —Continued

(Thousand short tons)

Country[1]	1974	1975	1976[p]
Africa:			
Algeria	154	138	165
Angola[e]	110	110	110
Dahomey	[r]6	6	[e]6
Egypt	549	551	530
Ethiopia:			
Rock salt	11	11	[e]11
Marine salt	134	84	[e]84
Ghana[e]	57	57	57
Kenya	33	6	16
Libya	11	11	[e]11
Malagasy Republic	[r e]29	29	30
Mali[e]	6	6	6
Mauritania[e]	1	1	1
Mauritius	6	6	[e]6
Morocco	40	46	[e]46
Mozambique	[r]34	35	[e]31
Niger[e]	2	1	1
Senegal	165	146	156
Somali Republic[e]	2	2	2
South Africa, Republic of	243	291	247
South-West Africa, Territory of:			
Marine salt	230	[r e]231	[e]231
Sudan	55	73	[e]77
Tanzania	38	49	24
Togo	[r]2	3	(2)
Tunisia	327	463	317
Uganda[e]	3	3	3
Asia:			
Afghanistan[5]	56	67	77
Bangladesh	187	827	615
Burma	[r]136	139	140
China, People's Republic of[e]	28,000	33,000	33,069
Cyprus	4	4	4
India	[r]5,812	3,672	4,938
Indonesia	77	57	[e]57
Iran[5]	440	440	772
Iraq[e]	[r]71	[r]71	71
Israel	126	129	95
Japan	1,229	1,177	1,125
Jordan	[r]28	18	28
Khmer Republic[e]	[r]33	[r]33	33
Korea, North[e]	600	600	600
Korea, Republic of	633	733	762
Kuwait	14	20	20
Laos	11	[r e]11	[e]11
Lebanon[e]	39	39	39
Mongolia[e]	12	12	12
Pakistan:			
Rock salt	[r]419	446	460
Other salt	148	140	156
Philippines	236	78	225
Ryukyu Islands[e]	[r]7	[r]7	7
Sri Lanka	133	131	155
Syrian Arab Republic	44	36	60
Taiwan	406	296	548
Thailand[e]	180	180	180
Turkey	1,007	816	87
Vietnam[e]	385	385	385
Yemen, People's Democratic Republic of[e]	83	83	83
Oceania:			
Australia[6]	[r]5,162	5,574	5,897
New Zealand	60	44	47
Total	[r]183,236	178,432	183,252

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Salt is produced in many other countries, but quantities are relatively insignificant or reliable production data is not available.
[2]Less than 1/2 unit.
[3]Series revised to include byproduct output from potash works, not previously included.
[4]Includes an average annual production in the Canary Islands of about 13,000 short tons of marine salt.
[5]Year beginning March 21 of that stated.
[6]Quantity shown is for 12 months ending June 30th of the year stated.

Saudi Arabia.—After a review of the country's second 5-year industrial development plan, the Saudi Arabian Government canceled Japanese contracts for two sea-water desalination plants at Jidda and Al Jubayl.[21]

Yemen Arab Republic.—The U.S.S.R. agreed to purchase Yemeni rock salt, part of which will be considered repayment of Soviet loans. With aid from Kuwait, the capacity of the As-Salif saltworks has been expanded to 500,000 tons per year.[22]

TECHNOLOGY

Researchers at the University of Delaware College of Marine Studies have been studying plants that thrive in saline soils to determine which are edible, their nutritional value, and the extent of irrigation they require. Many experts have noted that salt marsh production exceeds that of cultivated land, and coastal waters and marshes do not require the fertilization and energy that must go into cultivating most land.[23] Scientists at the University of California, Davis, have been engaged in an effort to find strains of crop plants that are able to tolerate salty environments. They have attempted to create, through selection and breeding, crop plants that can be grown in soil irrigated with brackish or salt water taken directly from the ocean or other sources. The use of water from saline sources could turn agriculturally useless land into productive areas.[24]

In Japan the first commercial reverse-osmosis, sea-water desalination plant was commissioned by Ohte Engineering. Developmental work had been undertaken by Envirogenics Co., a subsidiary of U.S. Aerojet General Corp. The concentration of sea-water salts in the processed water is below 300 parts per million (ppm).[25]

Imperial Chemical Industries Australia Ltd. started up the first full-size plant using a desalting process developed by them and Australia's Commonwealth Scientific and Industrial Research Organization. The process features ion-exchange resins that adsorb salts at a relatively low temperature of 20° to 30°C and that can be regenerated by washing with 90°C water. This method avoids the cost and environmental concerns of acid or alkali regeneration. Although it does not handle seawater, the system can accept brackish streams of up to 3,000 ppm salt, turning out water for drinking or industrial use.[26]

The U.S. Department of the Interior's Office of Water Research and Technology awarded an $85,000 contract to Gulf South Research Institute to develop new materials and techniques for desalting seawater.[27]

New scale-preventive chemical additives that have undergone successful testing in high-temperature multistage flash distillation units were presented at the 5th International Symposium on Fresh Water from the Sea. The established method of avoiding calcium carbonate and magnesium hydroxide scale on heat transfer surfaces of sea-water distillation plants has been by acid dosing with sulfuric acid. However, this measure can itself cause corrosion damage. To avoid acid, many plants have been designed for low-temperature, chemical-additive-dosed operation. However, the lower operating temperature results in reduced output compared with an acid-dosed plant. The new additives, therefore, combine the dual benefits of high-temperature, scale-free operation without acid.[28]

The Agricultural Research Service of the U.S. Department of Agriculture conducted experiments in which hides were preserved for as long as 28 days using acetic acid and sodium sulfite in place of salt. The researchers estimated that if U.S. leather processors used acid-sulfite curing on all hides stored less than 28 days, salt usage for domestic hide production could decline by 50%.[29]

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[21]European Chemical News. Technology Briefs. V. 29, No. 754, Sept. 24, 1976, p. 39.

[22]Industrial Minerals. Company News and Mineral Notes. No. 102, March 1976, p. 47.

[23]Rock Products. Saltwater Crops—Solution to Food Shortages? V. 79, No. 12, December 1976, p. 19.

[24]Rush, D. W., J. D. Norlyn, and E. Epstein. Salt-Resistant Crops Coming. Crops and Soils, v. 29, No. 13, December 1976, pp. 7-9.

[25]European Chemical News. In Brief. V. 29, No. 756, Oct. 8, 1976, p. 32.

[26]Chemical Engineering. Sirotherm Desalting Plant Starts Up in Australia. V. 83, No. 7, Mar. 29, 1976, p. 67.

Chemical Marketing Reporter. Mitsubishi and ICI Seen in Joint Venture on Ion Exchange Resin. V. 210, No. 8, Aug. 23, 1976, pp. 4, 28.

[27]Chemical Engineering. Companies. V. 83, No. 19, Sept. 13, 1976, p. 229.

[28]European Chemical News. Chemical Additives Prove Their Worth in Desalination Plants. V. 28, No. 738, May 28, 1976, p. 26.

[29]Chemical Marketing Reporter. Salt Pollution Cut in Leather Process. V. 210, No. 18, Nov. 1, 1976, p. 4.

Sand and Gravel

By James R. Evans[1]

In 1976, a total of 885 million tons of sand and gravel was reported sold or used in the United States. The f.o.b. value was $1.774 billion. Of these totals, construction sand and gravel was 855 million tons, with a value of $1.604 billion, and industrial sand and gravel was 30 million tons, with a value of $170 million.

Environmental Factors.—Environmental and reclamation factors continued to be of major concern to the sand and gravel industry throughout the United States.

Guidelines for limitations on existing

[1]Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Sand and gravel sold or used in the United States[1]

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
Sold or used:					
Construction:					
Processed:					
Sand:					
Quantity	330,384	346,996	322,607	265,404	418,495
Value	418,050	472,292	490,718	448,583	654,389
Gravel:					
Quantity	461,925	510,031	404,411	353,652	436,747
Value	607,263	706,329	683,408	634,931	949,405
Unprocessed:					
Sand and gravel:					
Quantity	92,485	97,627	148,558	143,097	(2)
Value	63,002	70,684	104,205	106,827	--
Total construction:[3]					
Quantity	884,794	954,654	875,576	762,153	855,242
Value	1,088,315	1,249,305	1,278,331	1,190,341	1,603,794
Industrial:					
Sand:					
Quantity	29,530	28,974	28,024	26,723	29,669
Value	112,386	110,065	135,357	146,982	169,127
Gravel:					
Quantity	--	--	1,046	560	245
Value	--	--	3,342	2,996	1,109
Total Industrial:[3]					
Quantity	29,530	28,974	29,070	27,283	29,914
Value	112,386	110,065	138,699	149,978	170,236
Total:[3]					
Quantity	914,324	983,629	904,646	789,436	885,156
Value	1,200,701	1,359,370	1,417,030	1,340,319	1,774,030
Exports:					
Quantity	1,821	1,744	2,256	3,219	3,692
Value[4]	7,178	8,597	11,664	15,047	19,516
Imports:					
Quantity	761	800	394	374	353
Value[5]	1,379	1,576	839	777	909

[1]Puerto Rico excluded from all sand and gravel statistics.
[2]Processed and unprocessed are no longer separated.
[3]Data may not add to totals shown because of independent rounding.
[4]F.a.s. (free alongside ship).
[5]Customs import value.

sources of wastewater discharges from sand and gravel operations into navigable water of the United States were published by the Environmental Protection Agency (EPA) in the Federal Register of June 10, 1976. These limitations are to be achieved by industry by July 1, 1977. Those who had existing permits from EPA, or from a State agency whose program was approved by EPA, could continue under the conditions of that permit until it expired. The 1977 limitations are defined as those achievable through application of the Best Practicable Control Technology currently available (BPT).

Possible environmental effects of sand and gravel mining in arctic and subarctic streams in Alaska were analyzed by Woodward-Clyde and Associates for the U.S. Fish and Wildlife Service. Thirty-one mining sites were examined in order to determine whether any relationship exists between sand and gravel extraction, the geomorphic characteristics of stream channels, and water quality and biological characteristics of the streams. The report, when completed in 1978, will be of great interest because of the increasing importance of sand and gravel in Alaska. Construction of the Trans-Alaska pipeline has resulted in the use of millions of tons of sand and gravel and has made Alaska the second largest producer in the United States from 1974 through 1976. Future similar projects in Alaska may result in a continuing large demand for Alaska's sand and gravel.

A new Michigan State law signed April 1, 1976, will require mining companies to obtain permits to mine dune sand within 1.5 miles of the lakeshore of Lake Michigan. In addition, an advance mining plan must be filed and land must be reclaimed after mining is complete. There are 6 mining companies working in at least 10 areas that will be affected by the new law. A royalty of 1 cent per ton must be paid by companies in order to finance the legislation.

River Rock Products Co.'s asphalt plant area, Fresno, Calif., won the 1976 first place Ecological Award given by the National Asphalt Pavement Association. This clean operation is on a 20-acre site that includes a three-hole golf course, lawns, landscaped drives, groves of more than 300 trees, flower borders, and a lake. Extensive ongoing maintenance is required to maintain the beauty of the site.

DOMESTIC PRODUCTION

The Pacific geographic region led the Nation in construction sand and gravel tonnage with 207 million, 24% of the national total (Figure 2, and tables 2 and 3). Next was the East North Central geographic region with 169 million tons, followed by the West North Central geographic region with 101 million tons. In industrial sand and gravel, the East North Central geographic region led the Nation with 12.5 million tons; 42% of the national total, and three times the tonnage of the second-place Middle Atlantic geographic region.

On a State basis, California led the Nation in construction sand and gravel sold or used, and in f.o.b. value (Table 4). Next, in order, were Alaska, Texas, Michigan, and Ohio. Collectively, these five States made up about 35% of the national total tonnage. The four leading States for industrial sand and gravel, in order, were Michigan, Illinois, New Jersey, and California. Their combined tonnage made up about 50% of the national total.

Sales and use of sand and gravel were reported from 7,599 deposits. Construction materials were extracted from 7,396 deposits; industrial materials, from 127; and both construction and industrial materials, from 76. Most of the tonnage came from deposits producing construction sand and gravel. More specifically, most of the tonnage came from deposits with sales and use levels over 200,000 tons (Table 11). Of the 7,396 construction sand deposits, only 1,023 were over the 200,000-ton level, but they accounted for 62% of the total tonnage.

There were 6,162 sand and gravel processing plants reported in operation. Of these, 5,593 plants were associated with extraction areas on land, and 569 plants were associated with dredging operations.

Most of the sand and gravel tonnages reported to the Bureau of Mines is that sold or used and not necessarily produced. Some companies produced more than they sold on the market, or sold to themselves as a user. Other companies, because of stockpiles, sold or used more than they produced. Over a period of a few years most companies' production would match their material sold or used.

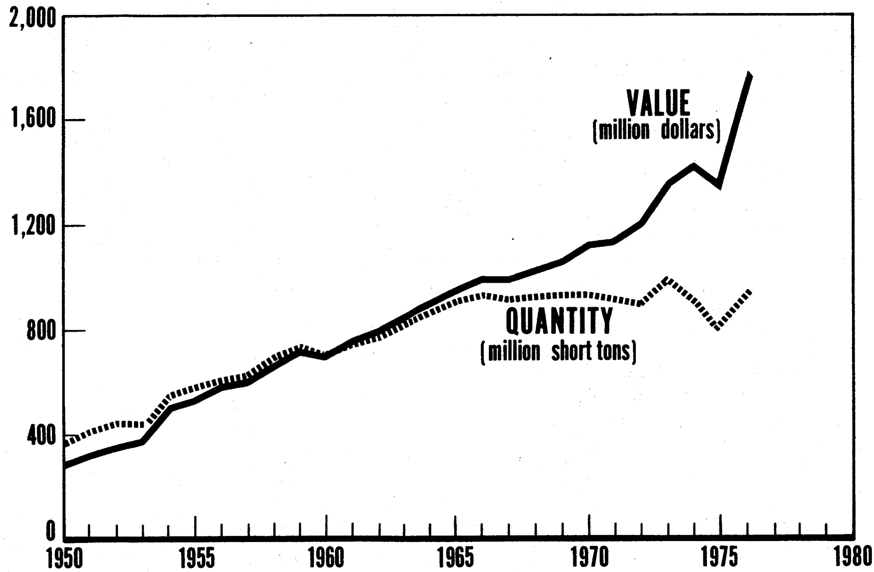

Figure 1.—Sand and gravel, quantity sold or used and value in the United States.

CONSUMPTION AND USES

The U.S. consumption of construction sand and gravel was equivalent to sales or use and was 855,242,000 tons, nearly 97% of all sand and gravel consumption. Of this total, about 33% went into concrete aggregates for use in residential and nonresidential buildings, and engineered construction such as highways, bridges, dams, waterworks, and airports. About 9% went into concrete products such as cement blocks, bricks, and pipe; 15% into asphaltic concrete aggregates and other bituminous mixtures, and 24% into roadbases and coverings for construction and repair of highways and roads. Nearly 16% went into fills and 3% into other unspecified uses (Table 5).

Table 6 shows the use pattern for construction sand and gravel by geographic region in the United States. The data indicates great differences between use categories and between certain geographic regions. For example, the Pacific geographic region leads the Nation in total construction sand and gravel, but the East North Central geographic region leads the Pacific in tons of concrete aggregates and concrete products sold or used. The Pacific geographic region, however, leads the Nation in tons of roadbases and coverings and fill. Table 7, which is based on data from table 6, shows a percentage breakdown by major use categories by geographic region. It aids in quickly determining the relative proportions of construction sand and gravel sold or used by major use category and geographic region.

Table 8 shows the major use categories for construction sand and gravel and tonnages sold or used. The top 10 States in this category are as follows, in thousand tons sold or used: California, 94,765; Alaska, 74,208; Texas, 46,571; Michigan, 42,067; Ohio, 37,790; Illinois, 34,300; Minnesota, 33,486; Wisconsin, 29,630; New York, 27,725, and Indiana, 25,518. These States made up 52% of the total national consumption.

Consumption of industrial sand and gravel in the United States was 29,914,000 tons. The top six States in this category are as follows, in thousand tons sold or used: Michigan, 5,336; Illinois, 4,484; New Jersey, 2,819; California, 1,827; and Texas and Oklahoma tied with 1,277 each. These States made up 57% of the total national consumption. Table 10 shows the major use categories for industrial sand and gravel. The three main uses (glassmaking, molding sand, and metal manufacture) accounted for 69% of the national total.

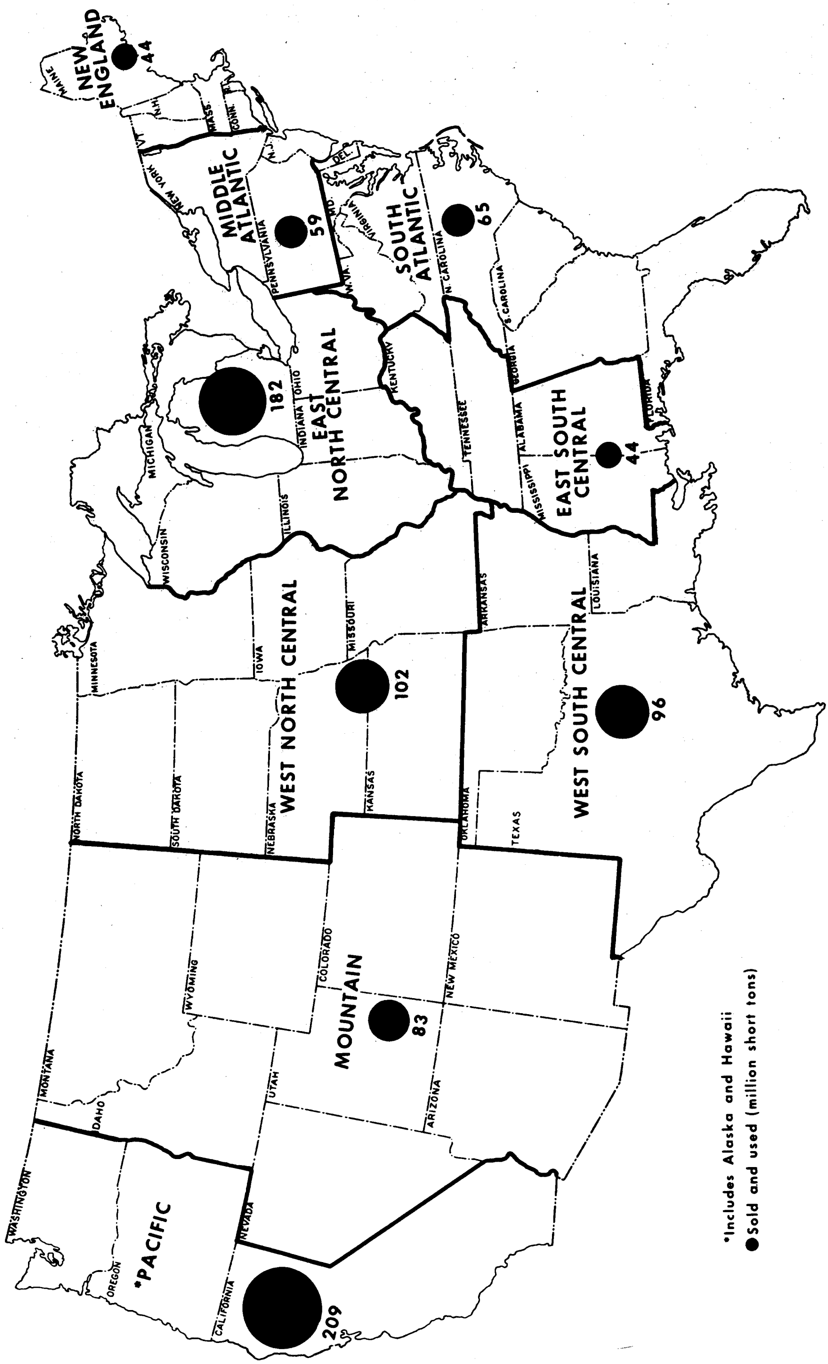

Figure 2.—Sand and gravel sold or used by geographic region.

PRICES

For purposes of this chapter, price means f.o.b. value of sand and gravel at the first point of sale or self-use. This value does not reflect any needed transportation from the plant, yard, or deposit to the consumer. It does, however, reflect those transportation costs needed to bring sand and gravel to the first point of sale or self-use by a company.

Based on this canvass, the national value per ton of construction sand was $1.56; gravel, $2.17; and sand and gravel $1.88. Industrial sand was $5.70; gravel, $4.39; and sand and gravel, $5.69. For all sand and gravel the national value per ton was $2.00.

Values per ton for major use categories for construction sand and gravel by State and for the United States are given in table 9. A significant difference in values between States and geographic regions as well as between major use categories is evident. Concrete products and concrete aggregates generally have the highest value per ton, at $2.11 and $2.08 respectively. Asphaltic concrete aggregates are close behind at $1.97; roadbases and coverings and fill follow at $1.69 and $1.58, respectively.

Values per ton for industrial sand and gravel were significantly higher than construction sand and gravel values: unground sand for glass, $5.72; metallurgical sand, $3.43; and foundry sand, $4.86 (table 10).

FOREIGN TRADE

Gravel, construction sand, and industrial sand were exported from the United States in 1976. As in 1975, nearly all of the materials went to Canada, with most of the remainder to Mexico and France.

Gravel exports were 579,359 short tons valued at $1,098,731 (f.a.s.), compared with 537,290 tons and $863,821 (f.a.s.) in 1975: 91% went to Canada, 1% to Mexico, and the remainder to 15 other countries. Construction sand exports were 558,733 tons valued at $1,336,721 (f.a.s.), compared with 510,859 tons and $1,111,410 (f.a.s.) in 1975: 97% went to Canada, 2% to Mexico, and the remainder to 27 other countries. Industrial sand exports were 2,533,475 tons valued at $17,079,590 (f.a.s.), compared with 2,171,109 tons and $13,071,346 (f.a.s.) in 1975: 63% went to Canada, 23% to France, 12% to Mexico, and the remainder to 62 other countries.

Construction sand and gravel and industrial sand were imported to the United States in 1976. The pattern was nearly the same as for 1975, with Canada and Australia the main import countries. Total tonnage of imports of construction sand and gravel was down about 11% from the 1975 level, and industrial sand was up about 35% from the 1975 level.

Construction sand and gravel imports totaled 292,112 tons valued at $424,764 (customs import value) and $624,377 (c.i.f. value). Slightly less than 99% of these imports came from Canada, 0.65% from West Germany, and the remainder from other countries.

Industrial sand imports totaled 60,670 tons, valued at $483,522 (customs import value) and $1,042,531 (c.i.f. value). Almost 97% of these imports came from Australia, 2.3% from Canada, and the remainder from six other countries.

WORLD REVIEW

Nearly all countries in the world use or produce sand and gravel of some kind. However, specific data for most countries is not available. The United States, Canada, the U.S.S.R., People's Republic of China, Mexico, Australia, France, West Germany, and the United Kingdom each consume more than 100 million tons annually. Probably the United States is the leading producer and consumer.

An important report on aggregates in the United Kingdom was published in 1976.[2] The report was prepared because of the crucial confrontation between the planning units of government and those in the industry who supply aggregates for construction. It was reported that in the southeast of England, where there is great concern for the environment, the sand and gravel industry has only about 15 years of

[2] Advisory Committee on Aggregates, Aggregates: The Way Ahead. Department of the Environment, Scottish Development Department, Welsh Office, Great Britain, 1976, p. 118.

life. Six important aspects of the problem with which the report dealt are as follows: (1) Extension of rail facilities for transportation of aggregates, (2) the possibility of restoring high-quality land, (3) reduction of constraints on marine dredging for sand and gravel, (4) more use of lightweight aggregates and slag and other waste materials, (5) the possibility of mining underground for aggregates, and (6) the creation of super quarries in granite rocks in the northern part of the United Kingdom for production of aggregates to be shipped by sea to the southeast of England.

A two-part perspective article on silica and silica sands was published in 1976. Production, consumption, and trade of silica in the United Kingdom, Europe, and Scandinavia were discussed in Part 1.[3] In Part 2, the same subject matter was treated for North and South America, Canada, Oceania, the Middle and Far East, and Africa.[4]

In Europe, the main deposits of silica sand are the Mol District of Belgium and the Fontainebleau region of France. West Germany and the Netherlands are also important silica-sand-producing countries. All of these countries export silica sand, which goes almost entirely to neighboring European countries. Lump silica for silicon and ferrosilicon production largely comes from Italy, Yugoslavia, Spain, and Portugal. These countries provide almost all of the needs of other European countries with the exception of France.

In North America, there is extensive cross trading between the United States and Canada of both silica sand and lump silica. Australia is self-sufficient in silica products and largely supplies the extensive South-East Asian market, particulary Japan.

TECHNOLOGY

During 1976 many reports were published concerning construction sand and gravel and industrial sand and gravel extraction and processing, and the use of waste material for aggregates. A brief description of some of the more significant publications follow.

Construction Sand and Gravel.—A map showing the sand and gravel and stone extraction areas in Fairfax County, Va., and their relation to geologic rock units was prepared by the U.S. Geological Survey.[5] The availability of construction materials and the urgency for local and regional planning to insure adequate future needs is described in a short text on the map sheet. Another similiar map published by the U.S. Geological Survey contained information concerning sand and gravel and other minerals in Prince Georges County, Md.[6]

Lone Star Industries, Inc., started construction on its new $12 million sand and gravel facility at Rancho Cordova, Sacramento County, Calif.[7] The deposit is in the flood plain of the American River. As at its former nearby facility in Fair Oaks, Lone Star mines rows of old gold dredge tailings. About 45 million tons or a 30-year supply is available. The processing plant will be able to produce a complete spectrum of construction aggregates. A concrete ready-mix plant and an asphaltic concrete hot-mix plant will also be built onsite. Stringent environmental controls are required, and the use permit has 22 separate operating conditions. Before construction begins, a 15-foot-high earth berm planted with trees will be built to screen the sand and gravel operation.

Columbia Sand and Gravel, a subsidiary of Columbia Consolidated Corp., Tucson, Ariz., opened a new sand and gravel pit.[8] A newly built plant, rated at 400 tons per hour on the dry circuit and 350 tons per hour on the wet circuit, produces pea gravel, roadbases, concrete sand, mortar sand, and block sand. Another Arizona company, Arizona Sand and Rock, opened a new operation on the Salt River (dry bed) near Mesa.[9] The site is leased from the Pima and

[3]Industrial Minerals. Silica: World Production, Consumption and Trade Part 1. May 1976, pp. 31-62.

[4]———. Silica: World Production, Consumption and Trade Part 2. June 1976, pp. 17-25.

[5]Froelich, A. J. Map Showing Mineral Resources of Fairfax County, Va., Availability and Planning for Future Needs. U.S. Geol. Survey Open File map 76-660, 1976.

[6]Hack, J. T. Map Showing Mineral Resources, Prince Georges County, Md. U.S. Geol. Survey map MF-768-A, 1968.

[7]Burns, J. Firm Plans Go-Ahead on Sand-Gravel Plant. Sacramento Bee, Sept. 13, 1976.

[8]Levine, S. Columbia Consolidated Readies New Sand and Gravel Plant for Its Concrete Operations. Pit and Quarry, v. 69, No. 2, Aug. 1976, pp. 66-68.

[9]Robertson, J. L. Dry River Bed Yields Raw Material. Rock Products, March 1976, pp. 95-97.

Maricopa Indian Tribes. A new 500-ton-per-hour plant supplies material to the adjacent concrete ready-mix and hot-mix asphalt plants. Knox County Sand and Gravel Co., Vincennes, Ind., built a 400-ton-per-hour processing plant to replace its old smaller capacity plant.[10] Ample reserves and an increasing demand indicated that the new plant was necessary. The new plant can deliver two gravel gradations and four sand gradations. Gifford-Hill and Co. put a new dredging system into operation that has resulted in greater production and less pump maintenance costs.[11] The deposit and plant are near Eagle Lake, Tex., along the banks of the Colorado River. The new system involves the use of two dredges, one as a digging dredge and the other a nearshore booster dredge to dig and transport material to the dewatering plant at about 475 tons per hour. This operation, which is the company's largest, produces about 1.8 million tons of sand and gravel per year. Owl Rock Co.'s Star operation near Anaheim, Calif., has been beset with raw-material-gathering problems.[12] A new wheel loader-conveyor combination, however, has solved the problems. Coherent conglomerate of tertiary age is blasted and moved down a steep slope by two track dozers and a backhoe equipped with a chisel instead of a bucket. Material has not moved properly downslope to the loading hopper. Therefore, it was necessary to excavate a bench about one-third of the way down slope from the mining area. Three 100-foot portable conveyors were set up on the bench to haul material across the bench to a dropoff point where it is then transferred to the delivery conveyor to the crushing plant. A 10-cubic-yard wheel loader feeds the portable conveyor system by dumping into a hopper.

Resurfacing of the five-lane upper deck of the San Francisco-Oakland Bay Bridge was accomplished by using a special 3/4-inch-thick layer of epoxy asphalt containing aggregate composed of a very hard metamorphosed sandstone.[13] The mixture provides a surface with increased skid-resistance and durability that traffic wear does not polish.

Two important reports were published by the Transportation Research Board. One had eight papers dealing with asphalts, aggregates, mixes, and stress-absorbing membranes.[14] The other report deals with procedures and criteria for setting density standards to control compaction during construction of granular base and subbase courses.[15]

Industrial Sand and Gravel.—Ford Glass Division's new Tulsa, Okla., plant is now operating with a second line. The two lines can produce about 1 million square feet of architectural and auto glass daily. Employment is 720 and the workers come from a 100-mile radius.[16]

Many foundries are now using reclaimed sand because transportation and/or purchase prices of new sand have risen significantly.[17] Cost saving can be significant since reclaimed sand makes better molds and cores and because grain size is more consistent, grains are rounder than for new sand, and many contaminants are removed. Consistent high-quality sand is provided for by reclamation, resulting in optimum binder use and production of a high-quality casting.

Waste Materials.—The Transportation Research Board published the results of a comprehensive survey of the technical and economic potential for employing waste materials in aggregates used in highway construction and maintenance.[18] There were two main objectives of the survey: (1) to inventory types, sources, and quantities of solid wastes potentially suitable for production of aggregates, and (2) to assess prospects for the practical use of such aggregates in highways, particularly when conventional aggregates are in short supply.

a new fusion process has been developed in which municipal refuse is incinerated into highway paving material.[19] The Refuse Residue Fusion Process is a five-step operation that starts with screening, includes firing at 1,800°F, and finally involves crushing and sizing to produce a product called eco-rock (ecologically sound, economical to

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[10]Herod, B. C. Indiana Operation Rebuilt With Best of Old, New Systems. Pit and Quarry, v. 68, 1976, pp. 81-83.

[11]Robertson, J. L. Dual Dredges Provide High Production, Low Maintenance. Rock Products, V. 79, No.8, Aug. 1976, pp. 74-78.

[12]Pit and Quarry. Wheel Loader/Conveyor Combination Solves Owl Rock's Material Gathering Problems. V.68, No. 11, May 1976, pp. 98-102.

[13]Engineering News Record. Bridge Overlay Has Special Anti-Skid Aggregates. V. 197, No. 6, Oct. 1976, p. 17.

[14]Transportation Research Board, National Academy of Sciences. Asphalts, Aggregates, Mixes, and Stress-Absorbing Membranes. Transport. Res. Record 595, 1976, p. 58.

[15]Roston, J. P., F. L. Roberts, and W. Baron. Density Standards for Field Compaction of Granular Bases and Subbases. Transportation Research Board, Nat. Academy of Sciences. Nat. Cooperative Highway Res. Program Rept. 172, 73 pp.

[16]Tulsa Daily World. Ford Glass Plant Running Around the Clock. Feb. 12, 1976.

[17]Smith, K. J. Foundry Sand Reclamation Techniques. Foundry Management and Technol., Nov. 1976, pp. 46-52.

[18]Miller, R. H., R. J. Collins. Waste Materials as Potential Replacements for Highway Aggregates. Transportation Research Board, Nat. Academy of Sciences. Nat. Cooperative Highway Res. Prog. Rept. 166, 1976, 94 pp.

[19]Pit and Quarry. Garbage, a New Aggregate Source. V. 68, No. 12, 1976, pp. 100-101.

produce). Twenty-seven tons (before crushing) of eco-rock was produced in a pilot plant in 1976. The product is reported to have excellent skid resistance. It will be tested for this and other properties in a wearing coarse at a site yet to be determined by the U.S. Department of Transportation.

The San Diego Division of California's Department of Transportation is substituting freeway sweepings for sand used in maintenance work and saving $2.50 per cubic yard in the process.[20] By 1975 500 cubic yards had been processed and plans are to increase output to 3,000 cubic yards per year in the greater San Diego area.

In northwestern Iowa rubble from old concrete pavement was used as aggregate for replacement pavements in an experimental program.[21] About 15,000 tons of rubble was processed to produce 5,500 tons of coarse crushed material that met specifications for paving about 2 miles of approaches to two replacement bridges on U.S. 75 south of Rock Rapids. Problems experienced were the peeling off of the asphalt overlay to eliminate bituminous material from rubble, control of fines in rubble, traffic control, setting up detours around the work areas, and scheduling for an independent contractor to haul off the broken pavement.

[20]Engineering News Record. Freeway Sweeping Recycled Into Pay Dirt. V. 197, No. 11, March 1976, p. 12.
[21]Highway and Heavy Construction. Concrete Pavement Recycled. V. 119, No. 9, Sept. 1976, pp. 30-31.

Table 2.—Sand and gravel sold or used in the United States in 1976, by geographic region

(Thousand short tons and thousand dollars)

Geographic Region	Construction		Industrial		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value
New England	44,199	74,946	147	963	44,346	75,909
Middle Atlantic	55,301	123,489	4,038	27,693	59,339	151,182
East North Central	169,305	271,291	12,521	58,569	181,826	329,859
West North Central	100,621	144,560	1,757	10,904	102,378	155,463
South Atlantic	61,440	118,218	3,841	22,942	65,281	141,160
East South Central	42,979	75,204	1,342	6,583	44,321	81,787
West South Central	92,225	181,425	3,419	23,741	95,647	205,169
Mountain	82,465	149,338	814	6,029	83,275	155,367
Pacific	206,710	465,325	2,032	12,811	208,742	478,136
Total[1]	855,242	1,603,794	29,914	170,236	885,156	1,774,030

[1]Data may not add to totals shown because of independent rounding.

Table 3.—Percent of sand and gravel sold or used in the United States in 1976, by geographic region

Geographic Region	Construction		Industrial	
	Quantity	Value	Quantity	Value
New England	5	5	1	1
Middle Atlantic	6	8	13	16
East North Central	20	17	42	34
West North Central	12	9	6	6
South Atlantic	7	7	13	13
East South Central	5	5	4	4
West South Central	11	11	11	14
Mountain	10	9	3	4
Pacific	24	29	7	8
Total	100	100	100	100

Table 4.—Sand and gravel sold or used, in the United States in 1976, by State

(Thousand short tons and thousand dollars)

State	Construction		Industrial		Total[1]	
	Quantity	Value	Quantity	Value		
Alabama	11,624	19,683	399	1,250	12,023	20,933
Alaska	74,208	204,738	--	--	74,208	204,738
Arizona	18,131	40,184	W	W	W	W
Arkansas	14,736	25,848	W	W	W	W
California	94,765	190,918	1,827	11,354	96,592	202,272
Colorado	20,160	32,900	W	W	W	W
Connecticut	6,414	12,978	--	--	6,414	12,978
Delaware	1,117	1,829	--	--	1,117	1,829
Florida	12,914	17,750	290	1,414	13,204	19,164
Georgia	4,520	6,484	315	1,903	4,835	8,387
Hawaii	573	1,634	--	--	573	1,634
Idaho	6,549	11,504	W	W	W	W
Illinois	34,300	61,759	4,484	25,393	33,784	87,152
Indiana	25,518	44,348	366	1,173	25,884	45,521
Iowa	15,206	26,277	W	W	W	W
Kansas	12,291	14,940	W	W	W	W
Kentucky	9,111	14,989	43	282	9,154	15,271
Louisiana	22,161	49,109	367	2,184	22,528	51,293
Maine	10,312	13,950	W	W	W	W
Maryland	12,942	31,914	--	--	12,942	31,914
Massachusetts	16,000	29,046	84	620	16,084	29,666
Michigan	42,067	58,257	5,336	20,198	47,403	78,455
Minnesota	33,486	44,503	W	W	W	W
Mississippi	12,033	20,394	W	W	W	W
Missouri	14,474	20,954	901	5,596	15,375	26,550
Montana	4,786	7,336	--	--	4,786	7,336
Nebraska	14,230	21,483	W	W	W	W
Nevada	9,116	16,519	555	3,587	9,671	20,106
New Hampshire	6,180	10,409	W	W	W	W
New Jersey	9,601	20,309	2,819	19,130	12,420	39,439
New Mexico	7,702	16,671	--	--	7,702	16,671
New York	27,725	55,326	156	806	27,881	56,132
North Carolina	8,309	14,344	740	3,943	9,049	18,287
North Dakota	5,171	8,345	--	--	5,171	8,345
Ohio	37,790	71,176	1,086	5,554	38,876	76,730
Oklahoma	8,760	11,975	1,277	7,075	10,037	19,050
Oregon	17,554	33,473	W	W	W	W
Pennsylvania	17,975	47,854	1,063	7,757	19,038	55,611
Rhode Island	2,914	4,805	W	W	W	W
South Carolina	7,110	11,802	777	5,352	7,887	17,154
South Dakota	5,763	8,057	--	--	5,763	8,057
Tennessee	10,211	20,138	885	4,991	11,096	25,129
Texas	46,571	94,496	1,277	8,721	47,848	103,217
Utah	10,547	13,442	W	W	W	W
Vermont	2,379	3,758	W	W	W	W
Virginia	10,191	23,089	W	W	W	W
Washington	19,610	34,562	203	1,455	19,813	36,017
West Virginia	4,337	11,006	W	W	W	W
Wisconsin	29,630	35,750	1,249	6,251	30,879	42,001
Wyoming	5,470	10,782	--	--	5,470	10,782
Total[1]	855,242	1,603,794	29,914	170,236	885,156	1,774,030

W Withheld to avoid disclosing individual company confidential data; included in "Total."
[1]Data may not add to totals shown because of independent rounding.

Table 5.—Construction sand and gravel sold or used in the United States, by use

(Thousand short tons and thousand dollars)

	1975		1976	
	Quantity	Value	Quantity	Value
Concrete aggregate (residential, nonresidential, highways, bridges, dams, waterworks, airports, etc.)	271,953	562,118	279,088	579,781
Concrete products (cement blocks, bricks, pipe, etc.)	61,295	125,711	78,059	164,540
Asphaltic concrete aggregate and other bituminous mixtures	115,494	222,887	127,576	251,210
Roadbase and coverings	187,474	232,542	208,563	352,970
Fill	104,781	91,122	136,854	216,463
Other uses	21,154	31,989	25,102	38,831
Total[1]	762,153	1,190,341	855,242	1,603,794

[1]Data may not add to totals shown because of independent rounding.

Table 6.—Construction sand and gravel sold or used in the United States, by geographic region and use

(Thousand short tons and thousand dollars)

Region	Concrete aggregate (residential, nonresidential, highways, bridges, dams, waterworks, airports, etc.)		Concrete products (cement blocks, bricks, pipe, etc.)		Asphaltic concrete and other aggregates, bituminous mixtures		Roadbase and coverings		Fill		Other uses		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
New England	11,633	24,889	3,800	8,869	6,581	13,579	10,106	12,094	8,929	10,815	3,154	4,699	44,199	74,946
Middle Atlantic	19,996	53,096	8,609	20,746	7,839	21,087	8,559	13,788	7,620	10,826	2,676	3,946	55,301	123,489
East North Central	58,649	107,248	15,212	26,647	35,948	62,405	34,270	46,788	21,383	23,504	3,845	4,699	169,305	271,291
West North Central	30,870	55,968	7,218	13,273	16,396	24,215	27,034	31,998	15,571	15,230	3,525	3,876	100,621	144,560
South Atlantic	23,611	50,629	12,614	27,587	4,358	9,168	10,367	18,400	7,395	7,734	3,096	4,699	61,440	118,218
East South Central	16,164	30,196	5,693	11,153	8,015	15,793	9,837	13,497	2,861	3,804	410	767	42,979	75,204
West South Central	42,030	92,806	8,900	20,622	10,363	24,534	15,241	24,024	13,731	15,498	1,960	3,941	92,225	181,425
Mountain	25,171	57,388	3,369	8,722	13,567	26,537	28,729	41,254	8,794	11,094	2,835	4,344	82,465	149,338
Pacific	50,964	107,567	12,641	26,926	24,511	53,892	64,419	151,131	50,566	117,953	3,605	7,856	206,710	465,325
Total[1]	279,088	579,781	78,059	164,540	127,576	251,210	208,563	352,970	136,854	216,463	25,102	38,831	855,242	1,603,794

[1]Data may not add to totals shown because of independent rounding.

Table 7.—Percent of construction sand and gravel sold or used in the United States in 1976, by geographic region

Region	Concrete aggregate (residential, nonresidential, bridges, dams waterworks, airports, etc.)		Concrete products (cement blocks, bricks, pipe, etc.)		Asphaltic concrete and other aggregates, bituminous mixtures		Roadbase and coverings		Fill		Other uses		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
New England	4	4	5	5	5	5	5	3	7	5	13	12	5	5
Middle Atlantic	7	9	11	13	6	8	4	4	6	5	11	10	6	8
East North Central	21	18	20	16	28	25	16	13	16	11	15	12	20	17
West North Central	11	10	9	8	13	10	13	9	11	7	14	10	12	9
South Atlantic	8	9	17	17	3	4	5	5	5	4	12	12	7	7
East South Central	6	5	7	7	6	6	5	4	2	2	2	2	5	5
West South Central	16	16	11	13	8	10	7	7	10	7	8	10	11	11
Mountain	9	10	4	5	11	11	14	12	6	5	11	11	10	9
Pacific	18	19	16	16	20	21	31	43	37	54	14	21	24	29
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 8.—Construction sand and gravel sold or used in the United States in 1976, by State and major use

(Thousand short tons and thousand dollars)

Region	Concrete aggregate (residential, nonresidential, highways, bridges, dams, waterworks, airports, etc.)		Concrete products (cement blocks, bricks pipe, etc.)		Asphaltic concrete and other aggregates, bituminous mixtures		Roadbase and coverings		Fill		Other uses		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	4,531	8,786	2,128	3,877	1,077	2,526	2,345	2,381	1,435	1,971	110	144	11,624	19,683
Alaska	576	2,651	89	391	134	669	36,220	100,532	36,979	100,014	210	482	74,208	204,738
Arizona	5,966	16,252	937	2,835	3,016	6,668	5,797	10,679	1,914	3,138	502	611	18,131	40,184
Arkansas	5,014	10,701	1,576	3,449	2,106	4,846	4,808	4,952	1,054	1,323	177	576	14,736	25,848
California	39,586	82,279	9,511	19,989	19,276	42,287	17,707	32,144	6,667	9,014	2,015	5,205	94,765	190,918
Colorado	6,280	13,137	657	1,811	2,188	3,342	8,617	11,082	1,637	2,274	782	1,253	20,160	32,900
Connecticut	1,346	3,715	925	2,037	1,042	2,392	1,213	2,182	1,654	2,134	234	516	6,414	12,978
Delaware	157	514	54	151	45	130	619	749	237	281	5	4	1,117	1,829
Florida	4,355	6,210	3,686	5,398	674	1,355	1,698	2,498	2,342	2,084	158	205	12,914	17,750
Georgia	2,518	3,624	582	1,319	133	372	512	527	732	574	45	70	4,520	6,484
Hawaii	130	423	35	201	34	202	181	487	99	133	92	187	573	1,634
Idaho	1,977	4,797	212	489	636	1,155	2,675	3,777	999	1,195	51	93	6,549	11,504
Illinois	13,469	25,727	2,613	4,911	6,721	11,677	6,443	11,926	4,628	6,842	428	677	34,300	61,759
Indiana	10,401	19,436	2,401	4,256	5,376	10,143	3,574	5,788	3,190	3,918	576	808	25,518	44,348
Iowa	5,444	11,647	1,379	2,870	2,867	5,301	3,538	3,896	1,679	2,134	298	429	15,206	26,277
Kansas	4,718	6,444	443	560	1,735	2,334	2,342	2,321	1,689	1,932	1,363	1,347	12,291	14,940
Kentucky	4,232	6,696	1,366	1,980	2,736	5,185	221	320	474	658	82	150	9,111	14,989
Louisiana	9,081	22,477	2,981	7,598	3,147	8,099	3,110	6,141	3,622	4,531	219	264	22,161	49,109
Maine	2,046	2,689	786	2,694	1,681	3,237	2,956	2,134	1,307	1,565	1,534	1,630	10,312	13,950
Maryland	5,130	14,068	1,975	5,299	736	1,846	3,554	7,674	873	1,503	671	1,524	12,942	31,914
Massachusetts	5,378	12,357	896	1,983	1,753	3,597	3,410	4,880	3,732	4,524	830	1,705	16,000	29,046
Michigan	12,371	21,501	5,462	8,600	7,153	11,450	10,933	11,676	4,850	3,611	1,299	1,419	42,067	58,257
Minnesota	7,511	14,073	3,151	5,863	6,855	8,489	10,637	11,589	4,278	3,496	1,054	992	33,486	44,503
Mississippi	3,889	7,464	609	1,434	2,871	5,402	4,215	5,611	411	470	36	17	12,033	20,394
Missouri	4,723	8,024	534	918	1,787	3,199	2,409	3,663	4,611	4,439	409	712	14,474	20,954
Montana	856	2,106	80	203	909	1,816	2,205	2,494	670	622	67	95	4,786	7,336
Nebraska	5,131	8,420	1,414	2,321	1,779	2,935	3,793	5,523	1,886	2,076	225	208	14,230	21,483
Nevada	2,687	5,538	627	1,031	1,937	4,308	2,960	4,354	782	867	122	422	9,116	16,519
New Hampshire	1,613	3,734	353	713	1,227	2,425	1,359	1,515	1,397	1,681	232	340	6,180	10,409
New Jersey	2,959	7,271	3,384	7,154	1,265	2,657	719	1,141	959	1,002	312	1,083	9,601	20,309
New Mexico	3,283	7,850	380	1,376	1,171	3,002	1,965	3,241	585	918	317	284	7,702	16,671

Table 8.—Construction sand and gravel sold or used in the United States in 1976, by State and major use —Continued

(Thousand short tons and thousand dollars)

Region	Concrete aggregate (residential, nonresidential, highways, bridges, dams, waterworks, airports, etc.)		Concrete products (cement blocks, bricks pipe, etc.)		Asphaltic concrete and other aggregates, bituminous mixtures		Roadbase and coverings		Fill		Other uses		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
New York	9,097	24,459	1,958	4,657	3,465	8,652	6,167	9,153	5,196	6,285	1,842	2,118	27,725	55,326
North Carolina	2,875	5,953	1,471	2,710	1,129	2,042	1,815	2,706	493	442	526	489	8,309	14,344
North Dakota	1,265	3,412	128	382	588	909	2,530	2,997	536	539	123	108	5,171	8,345
Ohio	14,089	28,429	2,850	5,842	11,494	22,857	3,613	6,491	4,570	6,183	1,172	1,375	37,790	71,176
Oklahoma	3,957	6,356	984	1,841	374	784	1,072	1,103	2,007	1,660	367	231	8,760	11,975
Oregon	4,834	9,727	474	1,076	2,982	6,171	6,214	12,086	2,183	3,286	869	1,126	17,554	33,473
Pennsylvania	7,940	21,366	3,267	8,935	3,109	9,778	1,673	3,494	1,465	3,539	522	745	17,975	47,854
Rhode Island	427	842	681	1,112	506	1,111	671	859	517	631	116	252	2,914	4,805
South Carolina	1,998	4,164	1,812	4,108	667	1,388	426	393	1,025	770	1,184	980	7,110	11,802
South Dakota	2,078	3,948	169	359	785	1,048	1,785	2,009	892	614	53	80	5,763	8,057
Tennessee	3,512	7,250	1,590	3,862	1,331	2,680	3,056	5,185	541	705	182	456	10,211	20,138
Texas	23,978	53,272	3,359	7,734	4,736	10,805	6,251	11,828	7,048	7,984	1,197	2,870	46,571	94,496
Utah	2,831	4,423	388	695	1,941	2,916	3,210	3,537	1,775	1,335	404	537	10,547	13,442
Vermont	823	1,553	159	330	372	817	497	524	322	280	208	256	2,379	3,758
Virginia	4,187	10,689	1,913	5,080	473	986	1,652	3,806	1,585	1,849	383	678	10,191	23,089
Washington	5,838	12,487	2,532	5,269	2,085	4,563	4,097	5,882	4,638	5,506	419	856	19,610	34,562
West Virginia	2,391	5,407	1,121	3,522	501	1,049	91	47	108	231	124	749	4,337	11,006
Wisconsin	8,319	12,155	1,886	3,038	5,204	6,278	9,707	10,907	4,145	2,950	370	420	29,630	35,750
Wyoming	1,291	3,285	88	282	1,769	3,330	1,300	2,090	432	745	590	1,049	5,470	10,782
Total[1]	279,088	579,781	78,059	164,540	127,576	251,210	208,563	352,970	136,854	216,463	25,102	38,831	855,242	1,603,794

[1]Data may not add to totals shown because of independent rounding.

Table 9.—Value per ton for construction sand and gravel sold or used in the United States in 1976, by State and by use

State	Concrete aggregate (residential, nonresidential, highways, bridges, dams, waterworks, airports, etc.)	Concrete products (cement blocks, bricks pipe, etc.)	Asphaltic concrete and other bituminous mixtures	Roadbase and coverings	Fill	Other uses	Overall average for all uses
Alabama	$1.94	$1.82	$2.35	$1.02	$1.37	$1.31	$1.69
Alaska	4.60	4.39	4.99	2.78	2.70	2.30	2.76
Arizona	2.72	3.03	2.21	1.84	1.64	1.22	2.22
Arkansas	2.13	2.19	2.30	1.03	1.26	3.25	1.75
California	2.08	2.10	2.19	1.82	1.35	2.58	2.01
Colorado	2.09	2.76	1.53	1.29	1.39	1.60	1.63
Connecticut	2.76	2.20	2.30	1.80	1.29	2.21	2.02
Delaware	3.27	2.80	2.89	1.21	1.19	.80	1.69
Florida	1.43	1.46	2.01	1.47	.89	1.30	1.37
Georgia	1.44	2.27	2.80	1.03	.78	1.56	1.43
Hawaii	3.25	5.74	5.94	2.69	1.34	2.03	2.86
Idaho	2.43	2.31	1.82	1.41	1.20	1.82	1.76
Illinois	1.91	1.88	1.74	1.85	1.48	1.58	1.80
Indiana	1.87	1.77	1.89	1.62	1.23	1.40	1.74
Iowa	2.14	2.08	1.85	1.10	1.27	1.44	1.73
Kansas	1.37	1.26	1.35	.99	1.14	.99	1.22
Kentucky	1.58	1.45	1.90	1.45	1.39	1.83	1.64
Louisiana	2.48	2.55	2.57	1.97	1.25	1.21	2.22
Maine	1.31	3.43	1.93	.72	1.20	1.06	1.35
Maryland	2.74	2.68	2.51	2.16	1.72	2.27	2.47
Massachusetts	2.30	2.21	2.05	1.43	1.21	2.05	1.82
Michigan	1.74	1.57	1.60	1.07	.74	1.09	1.38
Minnesota	1.87	1.86	1.24	1.09	.82	.94	1.33
Mississippi	1.92	2.35	1.88	1.33	1.14	.47	1.69
Missouri	1.70	1.72	1.79	1.52	.96	1.74	1.45
Montana	2.46	2.54	2.00	1.13	.93	1.42	1.53
Nebraska	1.64	1.64	1.65	1.46	1.10	.92	1.51
Nevada	2.06	1.64	2.22	1.47	1.11	3.46	1.81
New Hampshire	2.31	2.02	1.98	1.11	1.20	1.47	1.68
New Jersey	2.46	2.11	2.10	1.59	1.04	3.47	2.12
New Mexico	2.39	3.62	2.56	1.65	1.57	.90	2.16
New York	2.69	2.38	2.50	1.48	1.21	1.15	2.00
North Carolina	2.07	1.84	1.81	1.49	.90	.93	1.73
North Dakota	2.70	2.98	1.55	1.18	1.01	.88	1.61
Ohio	2.02	2.05	1.99	1.80	1.35	1.17	1.88
Oklahoma	1.61	1.87	2.10	1.03	.83	.63	1.37
Oregon	2.01	2.27	2.07	1.94	1.51	1.30	1.91
Pennsylvania	2.69	2.73	3.15	2.09	2.42	1.43	2.66
Rhode Island	1.97	1.63	2.20	1.28	1.22	2.17	1.65
South Carolina	2.08	2.27	2.08	.92	.75	.83	1.66
South Dakota	1.90	2.12	1.34	1.13	.69	1.51	1.40
Tennessee	2.06	2.43	2.01	1.70	1.30	2.51	1.97
Texas	2.22	2.30	2.28	1.89	1.13	2.40	2.03
Utah	1.56	1.79	1.50	1.10	.75	1.33	1.27
Vermont	1.89	2.08	2.20	1.05	.87	1.28	1.58
Virginia	2.55	2.66	2.08	2.30	1.17	1.77	2.27
Washington	2.14	2.08	2.19	1.44	1.19	2.04	1.76
West Virginia	2.26	3.14	2.09	.52	2.14	6.04	2.54
Wisconsin	1.46	1.61	1.21	1.12	.71	1.14	1.21
Wyoming	2.54	3.20	1.88	1.61	1.72	1.78	1.97
Total	2.08	2.11	1.97	1.69	1.58	1.55	1.88

Table 10.—Industrial sand and gravel sold or used in the United States, by use

(Thousand short tons and thousand dollars)

Use	1975			1976		
	Quantity	Value	Value per ton	Quantity	Value	Value per ton
Unground sand:						
Molding	6,455	32,371	$5.01	6,896	37,264	$5.40
Glass	10,211	54,703	5.36	11,467	65,551	5.72
Blast	1,371	11,812	8.62	1,498	9,946	6.64
Grinding and polishing	87	299	3.44	76	304	4.00
Fire or furnace	210	1,251	5.96	301	1,164	3.87
Engine	686	2,624	3.83	752	2,315	3.08
Filtration	191	1,381	7.23	183	1,060	5.79
Metallurgical	1,548	4,572	2.95	2,146	7,365	3.43
Oil (Hydrafac)	371	4,279	11.53	660	4,759	7.21
Other	2,601	12,983	4.99	2,251	14,430	6.41
Total	23,731	126,275	5.32	26,230	144,159	5.50
Ground sand:						
Filler	123	2,474	20.11	185	2,001	10.82
Chemical	115	869	7.56	40	611	15.28
Enamel	W	W	W	43	739	17.19
Abrasives	375	3,616	9.64	250	2,925	11.70
Foundry	1,554	6,467	4.16	1,741	8,455	4.86
Glass	535	3,463	6.47	878	6,294	7.17
Pottery, porcelain, tile	85	1,173	13.80	136	1,850	13.60
Other	206	2,646	12.84	168	2,094	12.46
Total	2,992	20,707	6.92	3,440	24,968	7.26
Gravel:						
Metallurgical	448	2,180	4.87	134	577	4.31
Other	112	816	7.29	110	532	4.84
Total	560	2,996	5.35	245	1,109	4.53
Grand total[1]	27,283	149,978	5.50	29,914	170,236	5.69

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.

Table 11.—Categories of sales and use levels for sand and gravel deposits[1]

Sales and use level	Construction				Industrial				Construction-Industrial			
	Deposits		Sales and use		Deposits		Sales and use		Deposits		Sales and use	
	Number	Percent of total	Thousand short tons	Percent of total	Number	Percent of total	Thousand short tons	Percent of total	Number	Percent of total	Thousand short tons	Percent of total
Less than 25,000	2,726	36.9	26,563	3.1	26	20.5	260	1.1	12	15.7	145	.7
25,000 to 49,999	1,161	15.7	41,573	5.0	28	22.1	1,044	4.2	8	10.5	309	1.5
50,000 to 99,999	1,335	18.1	92,558	11.0	22	17.3	1,549	6.3	10	13.2	713	3.4
100,000 to 199,999	1,151	15.5	160,193	19.1	16	12.6	2,377	9.6	13	17.1	1,927	9.1
200,000 to 299,999	436	5.9	102,958	12.3	11	8.6	2,683	10.9	10	13.2	2,501	11.8
300,000 to 399,999	208	2.8	71,026	8.4	4	3.2	1,406	5.7	9	11.8	3,181	15.0
400,000 to 499,999	108	1.4	48,079	5.7	5	3.9	2,225	9.0	2	2.6	936	4.4
500,000 to 599,999	85	1.2	46,042	5.5	2	1.6	1,092	4.4	3	4.0	1,654	7.8
600,000 to 699,999	49	.7	31,928	3.8	5	3.9	3,233	13.1	1	1.3	605	2.9
700,000 to 799,999	40	.5	29,970	3.6	3	2.3	2,227	9.0	1	1.3	786	3.7
800,000 to 899,999	24	.3	20,260	2.4	--	--	--	--	1	1.3	848	4.0
900,000 to 999,999	19	.3	18,174	2.2	1	.8	934	3.8	3	4.0	2,807	13.3
1,000,000 and over	54	.7	150,012	17.9	4	3.2	5,638	22.9	3	4.0	4,738	22.4
Total[2]	7,396	100.0	839,337	100.0	127	100.0	24,668	100.0	76	100.0	21,151	100.0

[1]An undetermined number of deposits leased from the Bureau of Land Management in Alaska are included as one deposit.
[2]Data may not add to totals shown because of independent rounding.

Table 12.—Number of sand and gravel deposits and processing plants in the United States in 1976,[1] by State

State	Number of deposits	Plants associated with extraction areas on land: Plants at site: Stationary	Plants associated with extraction areas on land: Plants at site: Portable	Plants associated with extraction areas on land: Plant not at site (stationary or portable)	Plants associated with extraction areas on land: No plant	Plants associated with dredging operation: On board	Plants associated with dredging operation: On land	Plants associated with dredging operation: No plant
Alabama	95	58	7	1	18	--	9	2
Alaska	52	9	19	1	22	1	--	--
Arizona	194	69	84	14	26	--	1	--
Arkansas	252	64	67	11	90	8	9	3
California	406	232	87	14	59	5	6	3
Colorado	232	48	133	7	32	7	3	2
Connecticut	79	32	41	1	5	--	--	--
Delaware	10	4	--	--	2	--	3	1
Florida	67	20	18	--	12	1	15	1
Georgia	64	22	12	1	22	2	5	--
Hawaii	9	1	5	1	2	--	--	--
Idaho	97	31	39	6	17	--	3	1
Illinois	190	56	90	2	24	4	11	3
Indiana	204	87	51	1	25	3	30	7
Iowa	211	63	121	1	17	1	8	--
Kansas	164	48	31	2	33	4	38	8
Kentucky	39	10	3	3	8	12	3	--
Louisiana	144	31	15	1	16	17	61	3
Maine	148	38	72	3	34	--	--	1
Maryland	71	31	10	2	24	--	3	1
Massachusetts	198	119	31	11	33	--	1	3
Michigan	432	120	238	11	53	--	6	4
Minnesota	398	93	238	25	40	--	1	1
Mississippi	66	21	13	1	14	1	16	--
Missouri	135	59	38	1	5	5	18	9
Montana	65	25	28	4	8	--	--	--
Nebraska	259	69	57	1	20	32	74	6
Nevada	95	37	39	7	12	--	--	--
New Hampshire	45	23	18	2	2	--	--	--
New Jersey	68	34	7	4	9	1	12	1
New Mexico	130	31	77	6	14	--	1	1
New York	471	153	198	15	91	1	2	11
North Carolina	152	31	34	4	69	1	9	4
North Dakota	70	14	43	1	12	--	--	--
Ohio	332	210	33	6	62	3	11	7
Oklahoma	132	29	18	3	38	7	30	7

Oregon	157	63	39	10	35	1	7	2
Pennsylvania	133	75	37	4	9	2	5	1
Rhode Island	30	15	9	2	3	--	--	1
South Carolina	80	19	9	1	33	3	12	3
South Dakota	136	24	72	1	39	--	--	--
Tennessee	93	29	18	3	29	5	7	2
Texas	252	172	13	10	39	2	7	9
Utah	85	28	46	2	9	--	--	--
Vermont	49	11	26	3	8	--	--	1
Virginia	109	42	11	1	43	2	2	8
Washington	203	65	73	11	49	--	2	3
West Virginia	10	2	1	--	1	5	1	--
Wisconsin	414	78	261	29	44	--	1	1
Wyoming	72	18	45	4	5	--	--	--
Total	7,599	2,663	2,675	255	1,316	136	433	121

[1] An undetermined number of deposits leased from the Bureau of Land Management in Alaska are included as one deposit.

Table 13.—Number of sand and gravel deposits and processing plants in the United States in 1976, by geographic region[1]

Region	Number of deposits	Plants associated with extraction areas on land: Plants at site: Stationary	Plants associated with extraction areas on land: Plants at site: Portable	Plants associated with extraction areas on land: Plant not at site (stationary or portable)	Plants associated with extraction areas on land: No plant	Plants associated with dredging operation: On board	Plants associated with dredging operation: On land	Plants associated with dredging operation: No plant
New England	549	238	197	22	85	--	1	6
Middle Atlantic	672	262	242	23	109	4	19	13
East North Central	1,572	551	673	49	208	10	59	22
West North Central	1,373	370	600	32	166	42	139	24
South Atlantic	563	171	95	9	206	14	50	18
East South Central	293	118	41	8	69	18	35	4
West South Central	780	296	113	25	183	34	107	22
Mountain	970	287	491	50	123	7	8	4
Pacific	827	370	223	37	167	7	15	8
Total	7,599	2,663	2,675	255	1,316	136	433	121

[1]An undetermined number of deposits leased from the Bureau of Land Management in Alaska are included as one deposit.

Table 14.—Transportation of sand and gravel to site of first sale or use in the United States

Method	1975		1976	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Truck	682,874	86	764,856	86
Rail	38,944	5	39,023	4
Waterway	30,315	4	33,177	4
Not shipped, used at site	31,107	4	35,221	4
Unspecified	6,196	1	12,880	2
Total[1]	789,436	100	885,156	100

[1]Data may not add to totals shown because of independent rounding.

Silicon

By Frederick J. Schottman[1]

Production and consumption of most silicon materials increased in 1976 over the depressed levels of 1975, and silicon metal production reached record high levels. Supplies were adequate, and while ferrosilicon prices were raised at midyear, silicon metal prices were unchanged, despite rising production costs. The relatively strong U.S. market attracted increased imports of ferrosilicon as worldwide industrial activity remained well below capacity.

Domestic producers continued construction programs intended to increase capacity and to meet environmental protection requirements. Foreign producers were also adding new capacity, much of it located in countries which had not previously been major producers of silicon materials.

DOMESTIC PRODUCTION

Production of silicon materials followed the general improvement in economic activity. Particularly large increases were made for silicon metal and miscellaneous silicon alloys.

Overall, production of ferrosilicon increased over the levels of 1975, but did not match those of 1973 and 1974. Production of 25% to 55% ferrosilicon was up 13% and shipments were up 29%. Shipments of 56% to 95% ferrosilicon increased 20%, but production increased only slightly. However, a significant portion of the production of 56% to 95% ferrosilicon in 1975 had gone into building up stocks, while 1976 production was more in balance with shipments. Since 1974, there was a shift from high-silicon-content ferrosilicon by domestic producers. On the basis of silicon content, about two-fifths of ferrosilicon alloys produced in 1974 were in the 56% to 95% class, compared with about one-fourth in 1976.

Production and shipments of silicon metal reached the highest levels ever with increases of 37% and 47%, respectively. Miscellaneous alloys showed increases of 15% in production and 28% in shipments. About three-fourths of the material in this class is magnesium ferrosilicon. Among other alloys included are calcium-silicon, silicon-manganese-zirconium, and rare-earth silicides.

Except for silicon metal stocks, which increased 34%, producers' stocks were little changed from the beginning of the year.

Several new plants and modernization projects were completed or under construction during the year. The new construction included both addition to capacity and replacement of obsolescent furnaces by more efficient and environmentally cleaner modern furnaces.

Ohio Ferro-Alloys Corp. completed a new silicon metal plant at Montgomery, Ala. The plant has three 20-megawatt (MW) furnaces with a capacity of 36,000 tons per year (tpy). A new 24-MW ferrosilicon furnace was completed by Airco, Inc., at its Niagara Falls, N.Y., plant. The Addy, Wash., plant of Northwest Alloys, Inc., a subsidiary of Aluminum Co. of America, began limited production in 1976. The plant is designed for a capacity of 16,000 tpy of silicon metal and 24,000 tpy of magnesium. The magnesium is produced using ferrosilicon smelted at the plant. A new ferrosilicon plant with a

[1]Physical scientist, Division of Ferrous Metals.

40-MW furnace was under construction by Tennessee Alloys Co. (TAC) at Bridgeport, Ala., with startup planned in 1977. The project is a joint venture between International Minerals & Chemical Corp., with a 75% interest, and Allegheny Ludlum Steel Corp. The new furnace will replace the three furnaces in the old TAC plant at Bridgeport and will result in a net increase in capacity of 50% to 75,000 tpy of 50% ferrosilicon.

In May 1976, the U.S. Environmental Protection Agency issued standards of performance for air pollution control systems for ferroalloy submerged arc furnaces, constructed or modified since October 1974. The standards set limits on the emission of particulates and carbon monoxide.

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1976

(Short tons, gross weight except as noted)

Alloy	Silicon content, percent		Producers' stocks as of Dec. 31, 1975[r]	Production	Shipments	Producers' stocks as of Dec. 31, 1976
	Range	Typical				
Silvery pig iron	5-24	18	W	W	W	W
Ferrosilicon (includes briquets)	25-55	48	57,505	524,486	485,926	54,417
Do	56-95	75	27,097	128,552	120,329	27,523
Silicon metal	96-99	98	13,884	141,617	131,067	18,564
Miscellaneous silicon alloys (excluding silicomanganese)[1]	32-65	--	17,934	90,119	83,233	17,256

[r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]Includes "Other silicon alloys and products" shown separately in previous years.

Table 2.—Producers of silicon alloys and/or silicon metal in the United States in 1976

Producer	Plant location	Product
Airco, Inc., Airco Alloys Div	Calvert City, Ky	FeSi.
Do	Niagara Falls, NY	Do.
Alabama Alloy Co., Inc	Bessemer, Ala	Do.
Aluminum Co. of America, Northwest Alloys, Inc	Addy, Wash	Do.
Chromasco, Ltd. Chromium Mining & Smelting Corp. Div	Woodstock, Tenn	Do.
Engelhard Minerals & Chemicals Corp., Philipp Bros. Div. Roane Electric Furnace Co	Rockwood, Tenn	Do.
Foote Mineral Co., Ferroalloys Div	Graham, W. Va	Do.
Do	Keokuk, Iowa	Silvery pig iron.
Hanna Mining Co., Hanna Nickel Smelting Co	Riddle, Oreg	FeSi.
Silicon Division	Wenatchee, Wash	FeSi, Si.
Interlake, Inc., Globe Metallurgical Div	Beverly, Ohio	Do.
Do	Selma, Ala	Si.
International Minerals & Chemical Corp., Industrial Minerals Div. Tennessee Alloys Co	Bridgeport, Ala	FeSi.
Tennessee Metallurgical Corp	Kimball, Tenn	Do.
Kawecki Berylco Industries, Inc. National Metallurgical Div	Springfield, Oreg	Si.
Ohio Ferro-Alloys Corp	Brilliant, Ohio	FeSi, Si.
Do	Montgomery, Ala	Si.
Do	Philo, Ohio	FeSi.
Do	Powhatan, Ohio	Si.
Reynolds Metals Co	Sheffield, Ala	Do.
Union Carbide Corp., Metals Div	Alloy, W. Va	FeSi, Si.
Do	Ashtabula, Ohio	FeSi.
Do	Marietta, Ohio	Do.
Do	Portland, Oreg	Do.
Do	Sheffield, Ala	Do.

CONSUMPTION AND USES

Reported consumption of silicon materials increased in 1976, compared with 1975 use. The increase followed closely the production trends for end uses such as cast iron and aluminum castings.

Consumption of 25% to 55% ferrosilicon

Table 3.—Consumption, by major end use, and stocks of silicon alloys and metal in the United States in 1976

(Short tons, gross weight except as noted)

End use	Silvery pig iron	Ferrosilicon[1]				Silicon metal	Miscellaneous silicon alloys[2]	Total silicon content[3]
Silicon content, percent: Range	5-24	25-55	56-70	71-80	81-95	96-99		
Typical	18	48	65	76	85	98	58	
Steel:								
Carbon	3,072	84,639	6,146	34,211	273	250	6,728	75,554
Stainless and heat-resisting	(4)	11,049	57	14,539	49	174	347	16,805
Full alloy	327	29,600	518	9,707	267	1,321	955	24,057
High-strength low-alloy	(4)	7,905	--	2,081	108	(4)	647	5,843
Electric	--	140	(4)	23,388	--	(4)	--	17,842
Tool	--	2,292	(4)	756	(4)	461	(4)	2,127
Unspecified	2,861	1,469	35	533	23	76	94	1,795
Total steel	6,260	137,094	6,756	85,215	720	2,282	8,771	144,023
Cast irons	41,266	234,905	3,752	32,678	2,067	29	92,102	202,659
Superalloys	2	296	--	4	86	67	1	285
Alloys (excluding alloy steels and superalloys)	620	6,126	6	369	277	57,278	412	59,942
Silicones	--	--	--	--	--	41,229	--	40,404
Miscellaneous and unspecified	2,562	2,089	1	429	--	2,546	5,245	7,328
Total	50,710	380,510	10,515	118,695	3,150	103,431	106,531	454,641
Percent of 1975	73	119	138	98	104	141	118	117
Total silicon content[3]	9,128	182,644	6,834	90,208	2,677	101,362	61,788	XX
Consumers' stocks, Dec. 31, 1976	5,855	31,804	762	16,892	573	10,147	7,952	44,660

XX Not applicable.
[1]Includes briquets.
[2]Includes magnesium-ferrosilicon and other silicon alloys.
[3]Estimated based on typical percent content.
[4]Included with "Unspecified."

increased 19% while that of 71% to 80% ferrosilicon, the other major grade, decreased slightly. Consumption of 56% to 70% and 81% to 95% ferrosilicon increased in 1976, but these grades remained a small part of the total ferrosilicon used. Since 1974, the data indicate a change away from the use of the higher grades of ferrosilicon toward the use of the 25% to 55% grade.

Cast iron remained the largest end use for ferrosilicon in 1976, and accounted for most of the reported increase in consumption. Steel, the other major end use, showed little change.

Silicon metal consumption increased 41%. For the two major end uses, which together accounted for over nine-tenths of the total, consumption in alloys (principally aluminum base alloys) and in silicones increased 37% and 57%, respectively. Silicones accounted for about two-fifths of the total. An important, but relatively low tonnage, application for silicon metal is as the raw material for the production of semiconductor silicon. This material is the basis for most semiconductor devices now produced. Advances in electronic device technology reduced the amount of silicon required to perform a function, but these same advances opened up new uses. Applications expanded rapidly, both in new products and as replacements for mechanical and electromechanical systems.

Yearend consumer stocks for all classes of materials were little changed from the beginning of the year.

PRICES

Prices for silicon materials were relatively steady in 1976. Supplies were adequate as demand recovered moderately from 1975 and new production capacity came onstream.

Domestic producers raised ferrosilicon

prices in June. On the basis of contained silicon, the price of 50% ferrosilicon was raised 2 cents to 34.5 cents per pound, and the price of 75% ferrosilicon was raised 0.5 cent to 37.0 cents per pound for standard grades, f.o.b. shipping point. The f.o.b. warehouse price of imported 75% ferrosilicon, as quoted in Metals Week, bottomed out at 28 to 30.5 cents per pound early in the year, after declining steeply in 1975, and rose to 30 to 31.5 cents per pound at yearend.

Prices for domestic silicon metal were unchanged during the year at 42.25 and 46.4 cents per pound for the 1% and the 0.35% maximum iron grades, respectively. Quoted prices for imported silicon metal declined from 42.5-44.5 cents per pound to 40-41 cents per pound.

FOREIGN TRADE

Exports of ferrosilicon were down 68% in quantity and 51% in value from 1975. Approximately 68% of the exports were to Canada which received 8,498 tons. Other major recipient nations were Brazil, with 1,349 tons, and Mexico, with 563 tons.

Ferrosilicon imports increased by 40% in quantity on a gross weight basis but decreased 5% in value. The quantity of 8% to 60% ferrosilicon doubled, with the increase coming from Canada, which provided 84% of the imports in 1976. Imports of 60% to 80% ferrosilicon rose 23% in quantity. Norway continued to supply the largest portion with 40% of the total. Other major suppliers were France (9%), India (9%), the Republic of South Africa (8%), Yugoslavia (8%), and Brazil (8%). Japan, which in earlier years had been an important source of both 8% to 60% and 60% to 80% ferrosilicon, shipped lower amounts to the United States in 1976. Shipments of 60% to 80% ferrosilicon to the United States from Taiwan and Canada also decreased significantly.

As in 1975, Norway, the Republic of South Africa, and Yugoslavia were the major sources of imported silicon metal, with 35%, 33%, and 22% of the total, respectively. West Germany and Japan supplied nearly all of the imported high-purity semiconductor grade silicon, which is included in the over 99.7% silicon import class.

Ferrosilicon containing 60% to 80% silicon and silicon metal with 99.0% to 99.7% silicon were among the materials from certain developing countries granted duty-free entry to the United States under the Generalized System of Preferences (GSP) starting January 1, 1976. During the year, the Office of the Special Representative for Trade Negotiations rejected a petition from the Ferroalloys Association that the treatment of ferroalloys under GSP be modified.

Table 4.—U.S. exports of ferrosilicon

Year	Quantity (short tons)	Value (thousands)
1974	6,575	$3,338
1975	38,452	15,281
1976	12,416	7,449

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country

Grade and country	1975 Quantity (short tons) Gross weight	1975 Quantity (short tons) Silicon content	1975 Value (thousands)	1976 Quantity (short tons) Gross weight	1976 Quantity (short tons) Silicon content	1976 Value (thousands)
Ferrosilicon:						
Over 8% but not over 60% silicon:						
Belgium-Luxembourg	64	29	$56	--	--	--
Canada	6,291	1,866	1,105	26,477	11,474	$7,201
Chile	--	--	--	150	70	41
France	2,863	1,450	2,211	2,114	1,039	1,320
Germany, West	284	154	528	736	406	1,411
Italy	38	18	14	19	8	10
Japan	4,318	2,027	4,021	1,113	557	814
Norway	1,451	634	1,059	966	429	571
United Kingdom	20	4	16	--	--	--
Total	15,329	6,182	9,010	31,575	13,983	11,368

See footnotes at end of table.

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country —Continued

Grade and country	1975 Quantity (short tons) Gross weight	1975 Quantity (short tons) Silicon content	1975 Value (thousands)	1976 Quantity (short tons) Gross weight	1976 Quantity (short tons) Silicon content	1976 Value (thousands)
Ferrosilicon —Continued						
Over 60% but not over 80% silicon:						
Argentina	--	--	--	55	41	$21
Australia	--	--	--	55	34	20
Belgium-Luxembourg	--	--	--	1,571	1,219	668
Brazil	342	256	$237	5,081	3,844	1,806
Canada	5,980	4,534	3,407	3,234	2,429	1,694
Chile	--	--	--	997	768	328
France	2,415	1,540	2,195	6,266	4,311	4,065
Germany, West	362	239	444	1,689	1,214	1,422
India	1,098	824	1,145	5,703	4,163	2,070
Japan	4,675	3,557	4,155	2,049	1,564	863
Korea, Republic of	298	225	269	--	--	--
Netherlands	585	418	328	--	--	--
Norway	27,689	20,685	13,188	26,197	19,742	10,488
Portugal	549	415	276	2,205	1,667	615
South Africa, Republic of	176	138	154	5,552	4,063	1,683
Spain	661	520	751	--	--	--
Sweden	4,519	3,389	1,857	--	--	--
Taiwan	3,964	2,976	2,780	145	110	62
Thailand	83	61	55	--	--	--
Yugoslavia	630	488	759	5,406	4,069	2,209
Total	54,026	40,265	32,000	66,205	49,238	28,014
Over 80% but not over 90% silicon:						
Canada	88	71	52	22	19	13
Chile	--	--	--	6	5	1
Japan	221	183	267	--	--	--
Portugal	56	50	70	--	--	--
Taiwan	--	--	--	110	89	92
United Kingdom	278	232	249	--	--	--
Vietnam, South	182	146	126	--	--	--
Yugoslavia	--	--	--	22	19	11
Total	825	682	764	160	132	117
Over 90% silicon:						
Canada	--	--	--	77	73	50
France	40	39	25	--	--	--
Netherlands	217	197	151	--	--	--
Norway	--	--	--	23	21	15
South Africa, Republic of	--	--	--	254	234	84
Total	257	236	176	354	328	149
Grand total	70,437	47,365	41,950	98,294	63,681	39,648
Silicon metal:						
Over 96% but not over 99% silicon:[1]						
Canada	--	--	--	309	([2])	252
France	--	--	--	66	([2])	46
Korea, Republic of	--	--	--	58	([2])	29
Norway	--	--	--	2,825	([2])	1,966
South Africa, Republic of	--	--	--	2,793	([2])	1,778
Switzerland	--	--	--	41	([2])	28
United Kingdom	--	--	--	1	([2])	13
Yugoslavia	--	--	--	2,164	([2])	1,421
Total	--	--	--	8,257	([2])	5,533
Over 99% but not over 99.7% silicon:						
Canada	--	--	--	238	236	196
France	--	--	--	110	109	72
Norway	1,316	1,298	1,080	552	545	442
South Africa, Republic of	1,878	1,846	1,153	369	365	240
Yugoslavia	516	510	472	--	--	--
Total	3,710	3,654	2,705	1,269	1,255	950

See footnotes at end of table.

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country —Continued

Grade and country	1975 Quantity (short tons) Gross weight	1975 Quantity (short tons) Silicon content	1975 Value (thousands)	1976 Quantity (short tons) Gross weight	1976 Quantity (short tons) Silicon content	1976 Value (thousands)
Silicon metal —Continued						
Over 99.7% silicon:						
Belgium-Luxembourg	(3)	(3)	$13	(3)	(3)	$44
Canada	(3)	(3)	5	19	19	16
Czechoslovakia	56	56	70	--	--	--
Denmark	(3)	(3)	134	1	1	407
Germany, West	30	30	2,054	65	65	3,689
Italy	1	1	43	(3)	(3)	17
Japan	15	15	1,145	19	19	1,045
Norway	95	95	136	--	--	--
Switzerland	1	1	270	--	--	--
United Kingdom	(3)	(3)	16	(3)	(3)	2
Total	198	198	3,886	104	104	5,220
Grand total	3,908	3,852	6,591	9,630	(2)	11,703

[1]New category effective January 1, 1976.
[2]Content data not available.
[3]Less than 1/2 unit.

WORLD REVIEW

Australia.—A new 45-million-volt-ampere (MVA) ferrosilicon furnace was commissioned by the Tasmanian Electrometallurgical Co. Pty. Ltd. (TEMCO), a subsidiary of Broken Hill Proprietary Co. Ltd. The furnace, located at Bell Bay, Tasmania, has a capacity of 28,000 tpy of 75% ferrosilicon.

Brazil.—Several companies are planning or installing additional ferrosilicon capacity totaling about 110,000 tpy. The companies include Alcan Alumínio do Brasil S.A., Cia. Paulista de Ferro-Ligas, Cia. Brasileira Carbureto de Calcio, Electrometalur SA, Italmagnesio SA, Ligas de Alumínio S.A. (Liasa), and Productos Metalurgicos Sampaio Lara Ltda.

Canada.—Production began at the Becancour, Quebec, plant of SKW Electro-Metallurgy Canada Ltd. The plant includes a 30-MW furnace and two 20-MW furnaces, and has a capacity of 25,000 tpy of 75% ferrosilicon and 25,000 tpy of silicon metal.

Iceland.—Elkem-Spigerverket A/S took over Union Carbide Corp.'s former interest in Icelandic Alloys Ltd. The Icelandic Government holds 55% interest in the company. Startup of the first furnace at the ferrosilicon plant under construction in 1976 is expected in 1978, with a second furnace due later.

Japan.—A 19,000 tpy ferrosilicon furnace was started at the Wakagawa plant of Japan Metals and Chemicals Co. Ltd., giving the company a capacity of 72,000 tpy.

Korea, Republic of.—Sam Chok Industrial Co. Ltd. began testing the furnace at its new silicon metal plant.

Venezuela.—Hornos Electricos de Venezuela S.A. (HEVENSA) installed two new furnaces to raise its capacity to 12,000 tpy of ferrosilicon.

Silver

By Harold J. Drake[1]

Domestic mine production of silver in 1976 totaled 34.3 million ounces,[2] a level of 2% below that of 1975. The decline in output was mainly attributed to a labor strike that shut down the Sunshine mine in Idaho for most of the year and the closure of several mines in Nevada. Refinery output in 1976 from domestic and foreign ores, coins, and old scrap totaled 104.6 million ounces compared with 111.2 million ounces in 1975. Most of the decline occurred in output of silver from foreign ores and concentrates and old scrap other than coins. Imports totaled 88.4 million ounces and exports totaled 14.6 million ounces. The excess of imports over exports was 73.8 million ounces compared with 57.8 million ounces in 1975. The general decline in the price of silver that began in the second half of 1975 was halted on January 26, 1976, when the average daily price per ounce reached 381.5 cents, the low for the year. The high for the year, 510.0 cents, was reached on July 6 with the price declining thereafter. The average daily price was 424.0 cents on January 5, 437.5 on December 30, and 435.4 cents for the year. The average monthly price followed an upward trend from 406 cents per ounce in January to 481 cents per ounce in June but declined rapidly thereafter and remained near 435 cents per ounce for the rest of the year.

Industrial consumption totaled 170.6 million ounces, an increase of 8% over that of 1975. An additional 1.3 million ounces was used in coinage. Significant increases were recorded for electroplated ware, photographic materials, mirrors, contacts and conductors, catalysts, and coins, medallions, and commemorative objects. Significant declines were recorded for sterling ware, jewelry, brazing alloys and solders, and batteries.

Private stocks of silver at yearend totaled 146.4 million ounces, down 11.9 million ounces from 1975. Government stocks, at 186.8 million ounces, were down 1.7 million ounces from the preceding year. Industrial stocks fell 4 million ounces to 30.6 million ounces and trading stocks at various commodity trading centers fell 8.4 million ounces to 115.8 million ounces. Treasury bullion stocks in the Bureau of the Mint were 39.7 million ounces at yearend, a level only slightly below that of yearend 1975. Silver available to defense contractors from the Department of Defense stocks totaled 7.6 million ounces at yearend. These stocks consisted of fine silver recovered from old scrap items collected mostly from various U.S. military services branches. The total amount of silver in the national stockpile remained at 139.5 million ounces, the same as at yearend 1975. On October 1, 1976, the Federal Preparedness Agency of the General Services Administration (GSA) issued new goals with the goal for silver set at zero. As a result, the 139.5 million ounces in the stockpile was surplus but congressional approval for disposal had not been given by yearend 1976.

Trading volume on the New York Commodity Exchange (COMEX) was 18.5 billion ounces in 1976 compared with 14.5 billion ounces in 1975. Trading volume on the Chicago Board of Trade (CBT) totaled 10.1 billion ounces compared with 9.8 billion ounces in 1975. COMEX warehouse stocks at the end of 1976 stood at 54.8 million ounces compared with 85.7 million ounces at yearend 1975. CBT stocks at yearend 1976 were 61.0 million ounces compared with 38.5 million ounces at yearend 1975.

Legislation and Government Programs.—Legislation was introduced in Con-

[1]Physical scientist, Division of Nonferrous Metals.
[2]Ounce as used throughout this chapter refers to the troy ounce.

gress, but not enacted, to authorize the disposal of approximately 118 million ounces of excess silver in the national stockpile. During 1976, GSA offered and sold by bid 696,205 ounces of silver reclaimed by various Federal agencies. The Bureau of the Mint struck the last of the 45 million 40% silver Bicentennial coins ordered by Congress.

Table 1.—Salient silver statistics

	1972	1973	1974	1975	1976
United States:					
Mine production .... thousand troy ounces..	37,233	37,484	33,762	34,938	34,328
Value .... thousands..	$62,737	$95,883	$159,018	$154,424	$149,328
Ore (dry and siliceous) produced:					
Gold ore............ thousand short tons..	1,579	3,817	2,033	2,251	1,993
Gold-silver ore .... do....	173	124	65	137	1,027
Silver ore .... do....	564	593	693	782	794
Percentage derived from:					
Dry and siliceous ores	31	30	30	35	32
Base-metal ores	69	70	70	65	68
Refinery production[1] ..... thousand troy ounces..	38,366	36,494	32,368	33,073	34,359
Exports[2] .... do....	29,657	11,215	18,390	32,626	14,596
Imports, general[2] .... do....	65,406	130,681	133,396	90,422	88,357
Stocks Dec. 31:					
Treasury[3] .... million troy ounces..	46	45	44	41	40
Industry[4] .... thousand troy ounces..	152,255	130,111	136,543	158,299	146,423
Consumption:					
Industry and the arts .... do....	151,663	196,386	176,027	157,650	170,559
Coinage .... do....	2,284	920	1,017	2,740	1,815
Price[5] .... per troy ounce..	$1.685	$2.558	$4.708	$4.420	$4.348
World:					
Production .... thousand troy ounces..	301,510	307,974	r292,184	297,882	304,899
Consumption[6]:					
Industry and the arts .... do....	r388,900	r471,300	r417,400	365,300	395,000
Coinage .... do....	38,400	r29,200	r27,700	29,200	27,000

rRevised.
[1]From domestic ores.
[2]Excludes coinage.
[3]Excludes silver in silver dollars.
[4]Includes silver in COMEX warehouses and silver registered in Chicago Board of Trade.
[5]Average New York price - Source: Handy & Harman.
[6]Market economies only - Source: Handy & Harman.

DOMESTIC PRODUCTION

Domestic mine production of recoverable silver decreased slightly to 34.3 million ounces equivalent to 20% of U.S. demand in 1976. Idaho accounted for 34% of the output, Arizona 22%, and Colorado 12%. Missouri, Montana, Utah, New Mexico, and Nevada, in the aggregate, accounted for 30% and eight other States accounted for the remainder. About 39% of the silver came from copper mining operations, 30% from silver ore, 14% from lead ore, and 13% from complex copper-lead-zinc ores. The remainder came from ores of gold, gold-silver, zinc, and from old tailings.

Refinery output of marketable silver totaled 104.6 million ounces, 52% of which came from concentrates and ores, both foreign and domestic, with the remainder coming from old scrap. Recovery from domestic ores and concentrates rose about 4%, whereas recovery from imported ores and concentrates continued to decline dropping by 26%. Production of silver from coins more than doubled which nearly offset a 22% decrease in output from other old scrap, and therefore. the amount of silver extracted from old scrap declined only 2% to 50.2 million ounces. Production of new scrap, 53.1 million ounces, was 5% above that of 1975.

The 25 leading silver producers (table 3) accounted for 81% of domestic production. Six of the leading producers mined silver ores while most of the remainder mined copper, lead, and zinc ores. Twelve of the leading mines produced in excess of 1 million ounces during 1976.

The largest silver mining district in the United States, Coeur d'Alene, Idaho, was reviewed in detail.[3] Major subjects of the review were the complex geology of the area and mining and metallurgical methods at the principal silver mines. Another report detailed the efficient mining operations at the Black Pine silver mine near Philips-

[3]Carters, R. A., and T. Li. Idaho's Coeur d'Alene District Sets Sights on Record Production. Min. Eng., v. 28, No. 7, July 1976, pp. 49-64.

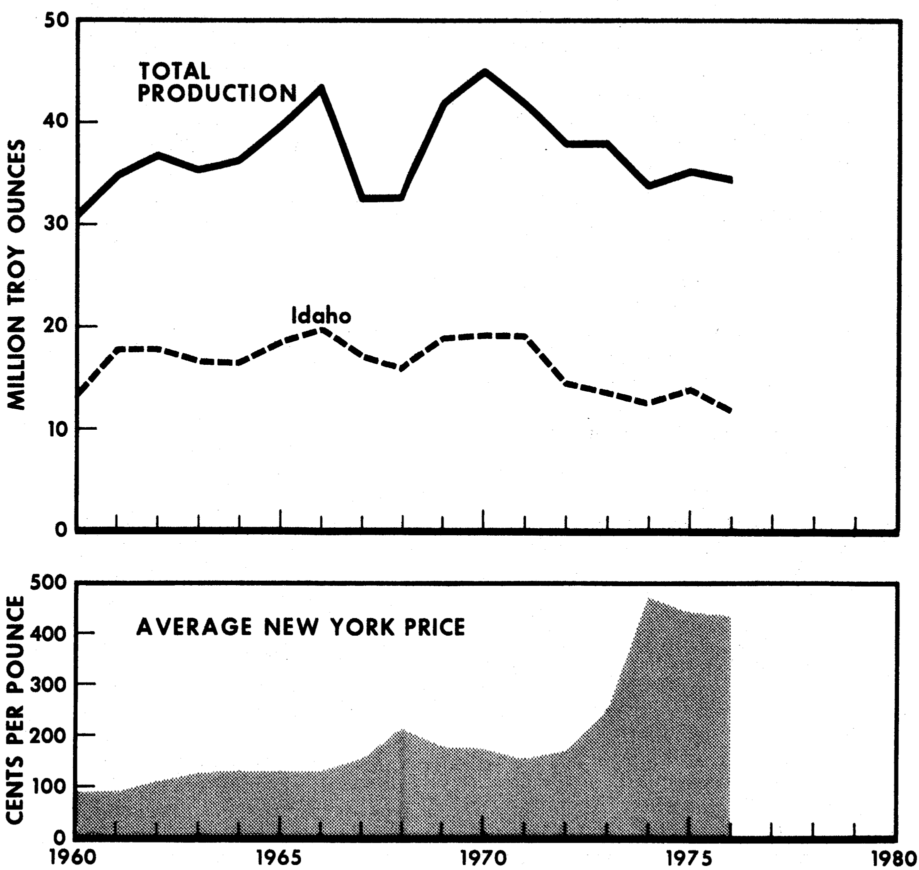

Figure 1.—Silver production in the United States and Idaho and price per ounce.

burgh, Montana.[4] The Black Pine mine produced 300 tons per day of ore with a per ton grade of 7.2 ounces of silver, 0.01 ounce of gold, and about 11 pounds of copper.

ASARCO Inc. reported that production of silver totaled 3.42 million ounces from its Galena mine, 0.67 million ounces from its share of the Coeur mine, and 0.22 million ounces from the Park City mine.[5] ASARCO continued to evaluate the Troy project, a copper-silver deposit in Montana, with a potential annual output of 4.2 million ounces of silver. The new Coeur mine went onstream in June and by yearend was operating at its design capacity of 2.2 million ounces of silver per year. Also in June, the company brought into commercial production a new copper refinery at Amarillo, Tex., with an annual capacity of 60 million troy ounces of silver.

Day Mines Inc. (DMI), Wallace, Idaho, reported a sharp increase in silver production to 1.95 million ounces in 1976.[6] DMI's Sherman mine in Colorado produced 53,514 tons of ore averaging 24.51 ounces of silver per ton. Other mines contributing to DMI's increased output were the Galena and Coeur mines in Idaho in which DMI has interests.

Earth Resources Co. (ERC) continued construction of the De Lamar silver mine in Idaho which was expected to be in operation by April 1977.[7] Exploration by ERC during 1976 more than doubled reserves thereby extending the estimated life of the mine from 10 years to more than 20 years.

Hecla Mining Co., Wallace, Idaho, reported a 1-million-ounce decline in production to 3.2 million ounces of silver in metallic concentrates in 1976.[8] The sharp decline in

[4] White, L. Trackless Mining on a Small Scale: Inspiration's Black Pine Silver Mine. Eng. Min. J., v. 177, No. 9, September 1976, pp. 98-100.
[5] ASARCO Inc. 1976 Annual Report. 32 pp.
[6] Day Mines Inc. 1976 Annual Report. 18 pp.
[7] Earth Resources Co. 1976 Annual Report. 25 pp.
[8] Hecla Mining Co. 1976 Annual Report. 28 pp.

production resulted from a nearby yearlong strike at the Sunshine mine which reduced considerably its output and, consequently, Hecla's share of that output. Hecla's Lucky Friday mine accounted for 82% of Hecla's output, the company's share of the Sunshine Unit area for 10% and, its share of the Star-Morning Unit area, for 7%. The remainder came as Hecla's share of the output from the Lakeshore mine. The Lucky Friday mine produced 2.64 million ounces of silver from 186,520 tons of ore for an average recovery of 14.16 ounces per ton. Tonnage was higher but grade was lower in 1976 than in 1975. Hecla's share of the Sunshine Unit area totaled 0.31 million ounces from 13,447 tons of ore averaging 23.05 ounces of silver per ton.

Production of silver by The Bunker Hill Co., Kellog, Idaho, a subsidiary of Gulf Resources & Chemical Corp., rose 12% to 7.79 million ounces.[9] Most of the silver came from the Bunker Hill mine in Idaho, which at yearend, contained 2.3 million tons of proven ore averaging 1.4 ounces per ton. An additional 0.78 million tons of the same grade was classed as probable ore. Bunker Hill's interest in the Star mine consisted of 0.51 million tons of proven ore and 0.19 million tons of probable ore, both of which averaged 4.0 ounces of silver per ton. Exploration at the company-owned Crescent mine resulted in the discovery of a new area of silver mineralization, the size of which had not been delineated by yearend.

Homestake Mining Co., reported silver production from its Bulldog mine in Colorado totaled 1.6 million ounces in 1976, up slightly compared with 1975.[10] The average grade of the 117,783 tons of ore mined in 1976 was 18.1 ounces per ton. Ore reserves of all types at yearend were 791,375 tons averaging 19.9 ounces of silver per ton.

CONSUMPTION AND USES

Industrial consumption of silver rose 8% to 170.6 million ounces in 1976. An additional 1.3 million ounces was used for coinage purposes, a level half that of 1975. Use in photographic materials, which accounted for one-third of consumption in 1976, rose 21% to 55.5 million ounces. Use in contacts and conductors, the second largest use category, rose 19% to 32.3 million ounces, whereas, the third largest use, sterling ware, declined 16%. In the aggregate, these three uses accounted for 63% of total industrial consumption in 1976. Use of silver in catalysts continued to increase and recorded a 40% gain to 12.3 million ounces. Use in electroplated ware rose 9% to 9.5 million ounces and use in coins, medallions, and commemorative objects rose 15% to 8.2 million ounces. Use in mirrors rose 47% to 4.6 million ounces and use in dental and medical supplies rose 29% to 1.9 million ounces. Declines in consumption were recorded for brazing alloys and solders, down 18% to 11.2 million ounces; jewelry, down 14% to 11 million ounces; and batteries, down 18% to 3.5 million ounces.

Certain applications appear to have excellent potential for an increased rate of growth in demand. The use of silver in solar energy applications was expanding. In this application, pure metallic silver is used in mirrors for collecting and concentrating the sun's rays which are then focused on boilers or other receivers used to generate electricity. Use of silver to purify water is growing because it can effectively control bacteria and other organisms found in water. Major applications includes swimming pool filters and filters that purify drinking water. Silver is being used to prevent buildup of static electricity in carpets and other types of woven material. In such applications silver is precipitated on a fiber which is eventually included with other fibers used to make the antistatic product.

STOCKS

Total accountable stocks at yearend were 333.2 million ounces. These consisted of 30.6 million ounces in industry stocks, 39.7 million ounces in Treasury stocks, 7.6 million ounces in Department of Defense stocks, 139.5 million ounces in the strategic stockpile, and 115.8 million ounces in COMEX and CBT registered vaults. COMEX warehouse stocks decreased 30.9 million ounces to 54.8 million ounces while CBT stocks rose 22.5 million ounces to 61.0 million ounces. Compared with total stocks at yearend 1975, a decrease of 14.1 million ounces was registered in 1976.

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[9] Gulf Resources & Chemical Corp. 1976 Annual Report. 44 pp.
[10] Homestake Mining Co. 1976 Annual Report. 35 pp.

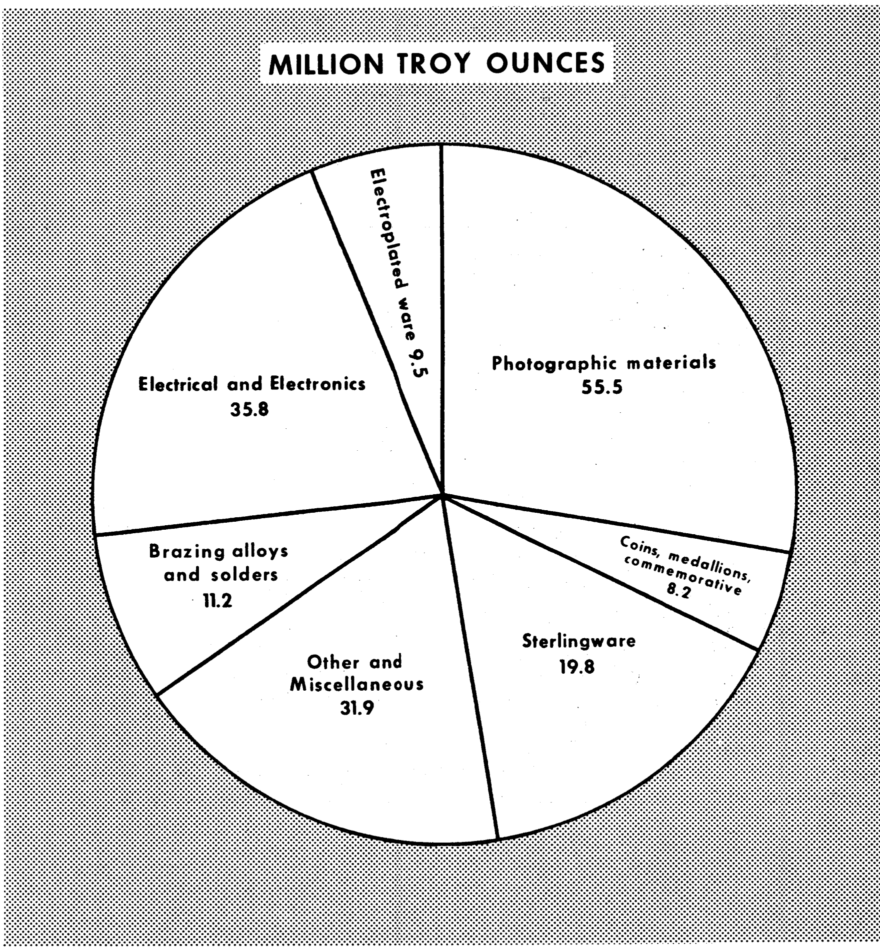

Figure 2.—Silver consumption in the United States, 1976.

PRICES

The price of silver fluctuated somewhat during 1976, rising in the first half then falling rather rapidly for the next few months. The price then rose slightly and remained fairly steady for the remainder of the year. The average daily price in cents per ounce of silver, as quoted by Handy and Harman, New York, began the year at 416.5, reached a low of 381.5 on January 26, a high of 510.0 on July 6, and finished the year at 437.5 on December 30. The gain in the average daily price in 1976 was 21.0 cents. The average monthly price was 406.3 cents per troy ounce in January, rose to 481.2 in June and 477.9 in July, and then declined sharply to 423.7 cents in August. A slight increase was then recorded in the final months to about 435.0. The average monthly price for the year was 435.4 cents per troy ounce compared with 441.8 cents in 1975.

Prices on the London Metal Exchange ranged from a low of 389.5 cents per ounce to a high of 507.6 cents per ounce (U.S. equivalent). The average for 1976 was 434.9 cents.

Trading volume on the COMEX was 18.5 billion ounces during 1976, an increase of 4.0 billion ounces over 1975. The CBT trading volume was 10.1 billion ounces, a gain of 0.3 billion ounces over that in 1975.

FOREIGN TRADE

Exports of silver fell 55% to 14.6 million ounces. Refined bullion, which accounted for 52% of total exports, totaled 7.6 million ounces, a level one-third that of 1975. Exports of waste, scrap, and sweepings declined 31% to 6.8 million ounces which was equivalent to 47% of total exports. Ore and concentrates, the remainder of the exports, totaled 0.16 million ounces. Japan, the principal foreign market in 1976 for exported material received 49% of the total; the United Kingdom, 20%; Belgium-Luxembourg, 11%; Taiwan, 4%; Spain, 3%; and Brazil and Switzerland 2% each. The remaining 9% went to about 10 countries. Bullion was shipped mainly to Japan, with significantly smaller amounts to Canada, Taiwan, and Brazil. Waste, scrap, and sweepings were sent to the United Kingdom, Belgium-Luxembourg, Japan, Spain, and Switzerland among others.

Imports of silver totaled 88.4 million ounces compared with 90.4 million ounces in 1975. Refined bullion accounted for 76% of total imports; ore and concentrates, 19%; waste and sweepings, 4%; and doré and precipitates the remainder. A 9% increase in imports of bullion to 67.2 million ounces was not enough to offset a 21% decrease in imports of ore and concentrates to 16.7 million ounces, a 40% decrease in imports of waste and sweepings to 3.3 million ounces, and a 45% decrease in imports of doré and precipitates to 1.2 million ounces.

The principal source for imported silver in 1976 was Canada which supplied 40.6 million ounces equivalent to 46% of total imports. Mexico supplied 18.4 million ounces or 21% of total imports, Peru 11.3 million ounces or 13%, and the United Kingdom 6.0 million ounces or 7%. Honduras, India, Japan, and Yugoslavia, in the aggregate, supplied 9.1 million ounces or 10% of total imports. The remaining 3% was supplied by a number of countries including Australia, Chile, Territory of South-West Africa, Italy, and the Philippines.

Most of the bullion imported in 1976 came from Canada, Mexico, Peru, and the United Kingdom. Ore and concentrates came mainly from Canada, Australia, Honduras, Mexico, Peru, Philippines, and South-West Africa. Canada accounted for most of the imports of waste and sweepings.

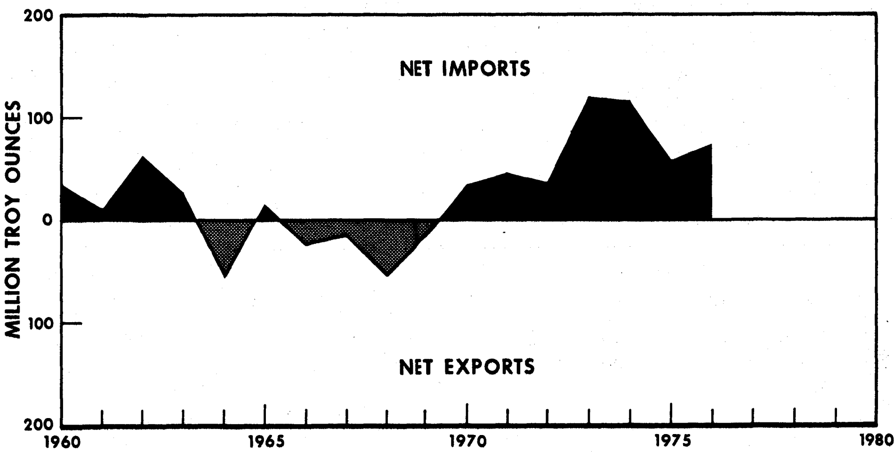

Figure 3.—Net exports or imports of silver, 1960-76.

WORLD REVIEW

World mine production of silver in 1976, including centrally planned economy countries, increased 2% to 305.0 million ounces. The United States, Canada, Mexico, and Peru accounted for 50% of world output.

World consumption of silver in 1976 for industrial and coinage uses, exclusive of centrally planned economy countries, totaled 422.0 million ounces compared with 394.5 million ounces in 1975.[11] A 19% increase in industrial use, which accounted for 94% of total use in 1976, was more than enough to offset an 8% decrease in use of silver in coinage. Total consumption by market economy countries exceeded newly mined supply by 178.0 million ounces according to Handy & Harman estimates. Secondary production supplied 40% of the difference, outflow from Indian stocks, 31%; demonetized coin, 28%; and U.S. and foreign Government stocks the remainder. West Germany was reported to have supplied an unusually high 28 million ounces of silver in 1976 reclaimed from official coins that had been retrieved by that Government.

Australia.—Production of silver rose 7% to 25.1 million ounces. An agreement was reached between Australian Mining & Smelting Ltd., St. Joe Minerals Corp., and Phelps Dodge Corp., to develop the Woodlawn lead-zinc-copper-silver deposits in New South Wales. The deposit contained about 11 million tons of proven reserves containing about 22 million ounces of silver in addition to other metals. An open pit mine was planned to be operational in about 2 years. The agreement calls for continued exploration around the Woodlawn ore body, particularly of sulfide occurrences similar to the main deposit. Western Selcast (Pty.) Ltd. and MIM Holdings Ltd. continued to explore the massive sulfide zone at their Teutonic Bore property in Western Australia. By yearend, several million tons of ore containing as yet unknown quantities of silver, copper, and zinc had been outlined. Diamond drilling of the deposit and metallurgical testing of the ore were continuing. Aquitaine Australia Minerals Pty. Ltd. and Serem Australia Pty. Ltd. continued to explore a major silver, lead, and zinc prospect near the town of Kunununa, in Western Australia.

Canada.—Mine production of silver in 1976 increased 3% to 40.9 million ounces.

[11]Handy & Harman. The Silver Market, 1976. 61st Annual Review, 1976, 22 pp.

Production of silver at the Kidd Creek mine of Texasgulf Canada Ltd. totaled 10.4 million ounces, about 13% above that of 1975.[12] At yearend, the mine contained a 205-million-ounce silver reserve above the 2,800-foot level. Exploration below this level continued to find ore so that the ultimate depth of the deposit had not been delineated at yearend. Texasgulf Inc. continued diamond drilling its large base metal sulfide deposits at Izok Lake and Hood River, Northwest Territories. At yearend, the exploration has delineated ore reserves containing 25 million ounces of silver at Izok Lake and about 1.0 million ounces at Hood River. Further drilling was planned to determine the extent of the deposits.

Mine production of silver by United Keno Hill Mines, Ltd. declined 19% to 2.4 million ounces.[13] Ore reserves declined from 208,000 tons averaging 37 ounces of silver per ton to 182,000 tons averaging 43 ounces per ton. Silver production at the Sturgeon Lake mine, a joint venture between Sturgeon Lake Mines, Ltd. and Falconbridge Copper Ltd., was 1.1 million ounces, a level only slightly above that of 1975.[14] Reserves at yearend 1976 totaled 1.4 million tons averaging 5.47 ounces of silver per ton.

Noranda Mines Ltd. reported silver production from the No. 12 and No. 6 mines of Brunswick Mining & Smelting Corp., Ltd. totaling 3.0 million ounces in 1976 compared with 4.4 million ounces in 1975.[15] Reserves at both mines at yearend totaled about 100 million tons containing 300 million ounces of silver. Noranda Mines Ltd. has a 64.1% interest in Brunswick Mining & Smelting Corp. Ltd. Noranda's Geco Div. reported production of 1.6 million ounces of silver in 1976 from an ore reserve that contained 41.0 million ounces at yearend. Production of silver by Mattagami Lake Mines Ltd. and Mattabi Mines Ltd. totaled 2.5 million ounces in 1976. Ore reserves of the two mines totaled 26.1 million ounces at yearend 1976. Noranda Mines Ltd. has operating interests in these mines.

Canex Placer Ltd., a subsidiary of Placer Development Ltd., was planning a mine-mill complex to exploit the Sam Goosley silver-gold-copper property located at Houston, British Columbia. The property was estimated to contain 43.5 million tons of ore containing 2.78 ounces of silver per ton. The Ruth Vermont silver-lead-zinc mine near Golden, British Columbia, began operating at near capacity from an ore reserve that contained an estimated 4 million ounces of silver.

Dominican Republic.—Rosario Dominicana, S.A. a subsidiary of Rosario Resources Corp., operated its new Pueblo Viejo base metal mine near capacity in 1976.[16] Production of doré bullion included 907,318 ounces of silver and 413,739 ounces of gold. Reserves of oxide ore totaled 25.8 million tons containing 18 million ounces of silver and 3 million ounces of gold. A sulfide ore reserve contained 19.5 million ounces of silver and 2.6 million ounces of gold. At yearend, a satisfactory metallurgical process to treat the sulfide ore had not been developed.

Honduras.—Production of silver in 1976 at the El Mochito mine of Rosario Resources Corp. totaled 3.2 million ounces. Ore reserves decreased during the year to 6.2 million tons containing 31.7 million ounces of silver and 12,340 ounces of gold, in addition to lead, zinc, and copper.

Japan.—Production (primary and secondary) and consumption of silver in 1976 totaled 37.9 million ounces and 57.0 million ounces, respectively. The supply deficiency was made up by imports of bullion and stock withdrawals. The principal uses were photography (which accounted for 45% of total consumption), contacts and conductors (12%), fabricated products (10%), and brazing alloys (8%).

Mexico.—Mine production of silver in 1976 totaled 42.6 million ounces. The extensive expansion of silver mines and plants of recent years did not result in the sharply increased output expected in 1976. However, production was still expected to increase by about 20 million ounces by the end of 1978.

Lacana Mining Corp., formed in 1975 through the merger of Lacanex Mining Co. Ltd., Pure Silver Mines Ltd., and Tormex Mining Developers Ltd., completed its first full year of operation in 1976.[17] The company has a 30% interest in Las Torres silver-gold mining complex in Guanajuato and a 40% interest in La Encantada silver-lead mine in Coahuila. It also has mining operations outside Mexico. Silver production at Las Torres complex in 1976 totaled 4.1 million ounces from an ore reserve that at yearend 1976 contained 46 million ounces of silver. When operating at full capacity, annual production at Las

[12]Texasgulf Inc. 1976 Annual Report. 48 pp.
[13]Falconbridge Nickel Mines, Ltd. 1976 Annual Report. 40 pp.
[14]Page 36 of reference cited in footnote 13.
[15]Noranda Mines, Ltd. 1976 Annual Report. 40 pp.
[16]Rosario Resources Corp. 1976 Annual Report. 32 pp.
[17]Lacana Mining Corp. 1976 Annual Report. 22 pp.

Torres should total 7.2 million ounces of silver. Silver production at the Encantado mine in 1976 totaled 1 million ounces. At yearend, silver reserves totaled 38 million ounces. Annual production at the La Encantada mine is expected to be 3.2 million ounces when operated at full capacity.

Expansion of the Huautla silver-lead mine in Morelos by Rosario Mexico, S.A. de C.V. continued in 1976.[18] Completion of the new crushing plant, which will increase the production rate from 140 tons of ore to 300 tons per day, was delayed until early in 1977. Silver production in 1976 totaled 546,817 ounces. At yearend, silver reserves stood at 8.0 million ounces.

Placer Development Ltd. Canada, continued to study its Real de Angeles silver property in Zacatecas. Diamond drilling in prior years outlined a deposit containing 43 million tons of ore averaging 2.5 million ounces of silver per ton. Plans in 1976 called for an open pit mine capable of producing 6 million ounces of silver per year to be in full production in 1979.

Production of silver at the Real del Monte mine, Hildago, was 4.0 million ounces in 1976.[19] Reserves were estimated at yearend to be about 30 million ounces.

Nicaragua.—Rosario Mining of Nicaragua, Inc., a subsidiary of Rosario Resources Corp. continued to explore the area around the Rosita mine and a large low-grade deposit of silver and gold in the Coco River area.[20] Mine and reserve development took precedence over production and as a result the mill at Rosita was not operated in 1976.

Peru.—Mine production of silver in 1976 totaled 35.6 million ounces compared with 37.5 million ounces in the preceding year. Partial financing for the planned expansion of the mining industry was extended to Empresa Minera del Centro del Peru, a wholly-owned subsidiary of Minero Peru, the Government-owned mining enterprise. Under the plan, the Cabriza copper-silver mine will expand annual output from 0.7 million tons of ore to 3.5 million tons of ore containing approximately 1.3 million ounces of silver. The Cuajone copper project began operating in late November 1976 with a rated mill capacity of 45,000 tons per day from a deposit grading 1% copper. In addition to primary copper, significant quantities of byproduct silver will be produced.

TECHNOLOGY

Researchers at the Bureau of Mines Reno, Nev. Metallurgy Research Center continued studies to develop economic methods for recovering silver and associated metals from low-grade or refractory ores. Much of the research dealt with heap leaching, activated carbon gold-silver recovery methods, and elevated-temperature pressurized stripping of gold and silver loaded carbon. Preliminary chemical refining tests were conducted on a silver sulfide precipitate to determine the feasibility of producing pure silver by a leaching-electrowinnning sequence. Research on the selective extraction of silver and copper from a complex sulfide concentrate from an antimony leach plant was continued. The concentrate was treated with an alkali sulfation roast followed by a sulfuric acid leach that resulted in the extraction of 99.5% of the silver and 99.7% of the copper. Refractory oxide silver ore was subjected to beneficiation tests to produce a silver-enriched limonite product for an acid-brine leach and a separate calcareous tailing. Results of the tests were inconclusive.

A rockburst monitoring system developed by the Bureau of Mines to warn of impending outbursts of rock was ready for commercial use.[21] The sensing elements of the monitoring system are geophones, extremely sensitive microphone-like instruments for detecting vibrations in rock. Strategically arrayed groups of geophones are linked to a computer that has been programed to pinpoint the origin of small-scale displacements, or microseismic events, that create minute noises the intensity and frequency of which can signal dangerously high stress. The monitoring system identifies zones where high stresses, that cause dangerous

[18]Page 9 of reference cited in footnote 16.

[19]Engineering and Mining Journal. New Silver Discoveries Provide Rescue for Mexico's Real del Monte Mine. V. 177, No. 9, September 1976, pp. 35-38.

[20]Pages 11 and 14 of reference cited in footnote 16.

[21]Blake, W., F. Leighton, and W. I. Duvall. Microseismic Techniques for Monitoring the Behavior of Rock Structures. BuMines Bull. 665, 1974, 65 pp.

rockbursts, can be relieved by detonating explosive charges in strategic locations. Such controlled blasts help prevent the rockbursts. A rockburst monitoring system designed by the Bureau of Mines is in use at ASARCO's Galena silver mine near Wallace, Idaho, and similar systems have been installed in the Lucky Friday silver mine and the Star silver mine both of which are adjacent to the Galena mine.

A study of energy use patterns in the production of silver was published.[22] The report detailed energy consumption in each operation in the production of metallic silver and concluded that total consumption of energy per ton of metallic silver amounted to 1.5 billion Btu's.

Innovative drilling and blasting techniques were developed at Texasgulf Canada, Ltd's, Kidd Creek base metal mine near Timmins, Ontario.[23] The underground operation utilizes a unique sublevel open stope method developed using large diameter blastholes bored with rotary drills.

Worldwide research on silver technology was reviewed.[24]

A method was developed for recovering silver adsorbed as a cyanide complex on activated charcoal.[25] Loaded charcoal is treated with sodium carbonate or potassium carbonate and then washed with deionized or softened water to dissolve the silver. Silver was removed from some ores using a flame formed by reacting hydrogen and chlorine, which volatilized the silver. The metal was then recovered by condensation and leaching.[26]

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[22]Battelle Columbus Laboratories. Energy Use Patterns in Metallurgical and Nonmetallic Mineral Processing (Phase 6 - Energy Data and Flowsheets, Low-Priority Commodities). BuMines Open File Rept. 117(1)-76, 1976, pp. 174-181; available for consultation at the Bureau of Mines libraries in Tuscaloosa, Ala., College Park, Md., Twin Cities, Minn., Rolla, Mo., Boulder City, Nev., Reno, Nev., Albany, Oreg., and Salt Lake City, Utah; National Library of Natural Resources, Department of the Interior, Washington, D.C.; and from National Technical Information Service, Springfield, Va., PB 261 150/AS.

[23]Blakey, P. N., T. R. Yu, and D. O. Tansey. Kidd Creek's Innovative Blasthole Sub level Stoping. Min. Eng., v. 28, No. 6, June 1976,. pp. 24-31.

[24]The Silver Institute. New Silver Technology. 1976, 237 pp.

[25]Davidson, R. J. Metal, Particularily Gold, Recovery From Absorbed Cyanide Complexes. U.S. Pat. 3,970,737, July 20, 1976.

[26]Oliver, R. E., and G. McGuire (assigned to Matthey Rustenburg Refiners (Pty.) Ltd.). Treatment of Material With Hydrogen Chloride. U.S. Pat. 3,998,926, Dec. 31, 1976.

Table 2.—Mine production of recoverable silver in the United States, by month

(Thousand troy ounces)

Month	1975	1976
January	3,048	2,909
February	2,708	2,948
March	2,920	3,073
April	3,013	2,831
May	2,904	2,574
June	2,993	2,913
July	2,805	2,622
August	2,842	3,039
September	2,867	2,962
October	3,016	2,828
November	2,743	2,855
December	3,079	2,775
Total	34,938	[1]34,328

[1]Data do not add to total shown because of independent rounding.

Table 3.—Twenty-five leading silver-producing mines in the United States in 1976, in order of output

Rank	Mine	County and State	Operator	Source of silver
1	Galena	Shoshone, Idaho	ASARCO Inc.	Silver ore.
2	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Copper ore.
3	Lucky Friday	Shoshone, Idaho	Hecla Mining Co	Lead ore.
4	Coeur	do	ASARCO Inc.	Silver ore.
5	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper ore.
6	Bulldog Mountain	Mineral, Colo	Homestake Mining Co	Silver ore.
7	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore.
8	Buick	Iron, Mo	Amax Lead Co. of Missouri	Lead ore.
9	Sunshine	Shoshone, Idaho	Sunshine Mining Co	Silver ore.
10	Twin Buttes	Pima, Ariz	Anamax Mining Co	Copper ore.
11	Sierrita	do	Duval Sierrita Corp	Do.
12	Sherman Tunnel	Lake, Colo	Day Mines, Inc	Silver ore.
13	Pima	Pima, Ariz	Cyprus Pima Mining Co	Copper ore.
14	Star Unit	Shoshone, Idaho	The Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
15	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper ore.
16	Magma	Pinal, Ariz	Magma Copper Co	Do.
17	Ontario	Summit, Utah	Park City Ventures	Lead-zinc ore.
18	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Copper ore.
19	Trixie	Utah, Utah	Kennecott Copper Corp	Gold-silver ore.
20	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
21	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
22	Magmont	Iron, Mo	Cominco American, Inc	Lead ore.
23	Mission	Pima, Ariz	ASARCO Inc	Copper ore.
24	Copper Canyon	Lander, Nev	Duval Corp	Do.
25	Crescent	Shoshone, Idaho	The Bunker Hill Co	Silver ore.

Table 4.—Silver produced in the United States, in 1976, by State, type of mine, and class of ore, yielding silver, in terms of recoverable metal

State	Placer (troy ounces of silver)	Lode: Gold ore, Short tons	Lode: Gold ore, Troy ounces of silver	Lode: Gold-silver ore, Short tons	Lode: Gold-silver ore, Troy ounces of silver	Lode: Silver ore, Short tons	Lode: Silver ore, Troy ounces of silver
Alaska	1,808	463	112	--	--	--	--
Arizona	--	W	W	W	W	53,152	164,323
California	163	5,526	1,279	2,225	15,657	50	389
Colorado	--	36,317	4,643	589	8,970	196,061	2,699,952
Idaho	--	91	91	72	689	466,762	6,885,167
Michigan	--	--	--	--	--	--	--
Missouri	--	--	--	--	--	--	--
Montana	--	3,711	1,588	5,121	27,409	68,122	309,226
Nevada	100	228,998	47,927	W	W	9,237	119,874
New Mexico	--	10,455	2,458	3,776	10,311	128	1,859
New York	--	--	--	--	--	--	--
South Dakota	--	1,658,132	58,117	--	--	--	--
Other States[1]	--	49,081	124,948	1,014,738	598,922	244	6,595
Total	2,071	1,992,774	241,163	1,026,521	661,958	793,756	10,187,385
Percent of total silver	(2)	--	1	--	2	--	30

State	Lode: Copper ore, Short tons	Lode: Copper ore, Troy ounces of silver	Lode: Lead ore, Short tons	Lode: Lead ore, Troy ounces of silver	Lode: Zinc ore, Short tons	Lode: Zinc ore, Troy ounces of silver
Alaska	--	--	78	1,345	--	--
Arizona	173,325,593	7,276,850	213	336	--	--
California	--	--	--	--	W	W
Colorado	--	--	206	382	178,945	108,650
Idaho	W	W	187,733	2,592,878	W	W
Michigan	3,801,271	310,837	--	--	--	--
Missouri	--	--	8,657,845	2,277,013	--	--
Montana	16,780,787	2,935,682	488	4,326	W	W
Nevada	3,057,651	486,325	--	--	W	W
New Mexico	25,015,712	765,800	W	W	W	W
New York	--	--	--	--	1,112,553	49,199
South Dakota	--	--	--	--	--	--
Other States[1]	29,707,680	1,778,751	3,771	42,865	695,913	147,836
Total	251,688,694	13,554,245	8,850,334	4,919,145	1,987,411	305,685
Percent of total silver	--	39	--	14	--	1

State	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores, Short tons	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores, Troy ounces of silver	Lode: Old tailings, etc., Short tons	Lode: Old tailings, etc., Troy ounces of silver	Lode: Total[3], Short tons	Lode: Total[3], Troy ounces of silver
Alaska	--	--	--	--	541	3,265
Arizona	91,378	33,763	40,985	15,098	174,451,346	7,615,112
California	--	--	W	W	10,101	57,265
Colorado	882,466	1,260,574	--	--	1,294,584	4,083,171
Idaho	1,132,543	2,025,916	--	--	1,959,630	11,561,421
Michigan	--	--	--	--	3,801,271	310,837
Missouri	--	--	--	--	8,657,845	2,277,013
Montana	--	--	W	W	16,858,301	3,278,629
Nevada	77,450	99,830	--	--	3,382,711	783,892
New Mexico	--	--	--	--	25,161,206	891,932
New York	--	--	--	--	1,112,553	49,199
South Dakota	--	--	--	--	1,658,132	58,117
Other States[1]	2,956,945	990,163	37	[4]31,234	33,173,073	3,358,377
Total	5,140,782	4,410,246	41,022	46,332	271,521,294	34,328,230
Percent of total silver	--	13	--	(2)	--	100

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1]Includes Illinois, Maine, Tennessee, Utah, Virginia, Washington, and States indicated by symbol W.
[2]Less than 1/2 unit.
[3]Data may not add to State totals because of items withheld to avoid disclosing individual company confidential data.
[4]Includes byproduct silver recovered from tungsten ore in California and fluorspar in Illinois.

Table 5.—Mine production of recoverable silver in the United States, by State

(Troy ounces)

	1972	1973	1974	1975	1976
Alaska	288	828	547	W	3,265
Arizona	6,652,800	7,199,251	6,355,528	6,285,854	7,615,112
California	175,467	55,897	41,894	79,757	57,265
Colorado	3,663,832	3,598,209	2,783,978	3,366,000	4,083,171
Idaho	14,250,725	13,619,824	12,435,701	13,868,133	11,561,421
Maine	16,251	W	W	W	W
Michigan	785,100	850,273	642,944	632,336	310,837
Missouri	1,971,530	2,057,732	2,387,250	2,525,042	2,277,013
Montana	3,325,052	4,349,869	3,512,161	2,616,626	3,278,629
Nevada	595,351	623,660	872,243	1,608,735	783,892
New Mexico	1,016,880	1,111,269	1,194,800	792,050	891,932
New York	25,070	54,345	64,463	56,047	49,199
Oregon	2,252	1,282	8,925	W	--
South Dakota	99,992	71,939	62,474	67,669	58,117
Tennessee	83,466	73,104	20,053	53,752	77,890
Utah	4,299,604	3,619,038	3,207,923	2,821,730	3,134,021
Other States	269,262	197,050	170,990	163,851	146,466
Total	37,232,922	37,483,570	33,761,874	34,937,582	34,328,280

W Withheld to avoid disclosing individual company confidential data; included in "Other States."

Table 6.—Silver produced in the United States from ore, old tailings, etc., in 1976, by State and method of recovery, in terms of recoverable metal/

State	Total ore, old tailings, etc. treated[1,2] (thousand short tons)	Ore and old tailings to mills					Crude ore, old tailings, etc., to smelters[1]	
		Thousand short tons[1,2]	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Thousand short tons	Troy ounces
Alaska	1	1	--	--	7	112	(3)	1,345
Arizona	[4]195,242	[4]194,900	--	125,000	3,277,536	7,309,435	342	180,677
California	10	10	625	--	2,492	54,124	(3)	2,353
Colorado	1,295	1,294	838	15,116	152,025	4,038,654	1	28,563
Idaho	1,960	1,959	7	--	170,756	11,553,973	1	7,441
Michigan	3,801	3,801	--	--	143,236	310,837	--	--
Missouri	8,658	8,658	--	--	882,320	2,277,013	--	--
Montana	16,884	16,788	357	--	338,063	2,940,859	96	337,413
Nevada	[4,5]13,753	[4,5]13,712	35	156,569	201,133	615,355	41	11,833
New Mexico	[4]25,189	[4]25,106	--	1,417	788,429	877,185	83	13,330
New York	1,239	1,239	--	--	137,949	49,199	--	--
South Dakota	1,658	1,658	--	58,117	--	--	--	--
Tennessee	5,159	5,159	--	--	222,815	77,890	--	--
Utah	30,053	29,937	--	--	723,132	2,667,767	116	466,254
Other States[6]	1,128	1,128	--	51,156	81,032	92,139	(3)	3,171
Total	306,030	305,350	1,862	407,375	7,120,925	32,864,542	680	1,052,380

[1]Includes some nonsilver-bearing ore not separable.
[2]Excludes tonnages of fluorspar, tungsten, and uranium ores from which silver was recovered as a byproduct.
[3]Less than 1/2 unit.
[4]Includes ore from which silver was recovered by heap leaching.
[5]Includes ore from which silver was recovered by vat leaching.
[6]Includes Illinois, Maine, Virginia, and Washington.

Table 7.—Silver produced at amalgamation and cyanidation mills in the United States and percentage of silver recoverable from all sources

Year	Bullion and precipitates recoverable (troy ounces)		Silver recoverable from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting[1]	Placers
1972	2,490	99,992	0.01	0.27	99.72	(2)
1973	3,536	260,846	.01	.70	99.29	(2)
1974	2,467	335,909	.01	.99	99.00	(2)
1975	2,293	420,077	.01	1.20	98.79	(2)
1976	1,862	407,375	(2)	1.19	98.80	0.01

[1]Crude ores and concentrates.
[2]Less than 0.005%.

Table 8.—Silver produced at refineries in the United States, by source

(Thousand troy ounces)

Source	1975[r]	1976
Concentrates and ores:		
Domestic	33,073	34,359
Foreign	27,004	19,994
Total[1]	60,078	54,353
Old scrap:		
Coins	7,004	15,945
Other	44,104	34,280
Total[1]	51,107	50,225
Total net production	111,185	104,578
New Scrap	50,520	53,084
Grand total	161,705	157,662

[r]Revised.
[1]Data may not add to total shown because of independent rounding.

Table 9.—U.S. consumption of silver, by end use

(Thousand troy ounces)

Final use[1]	1975	1976
Electroplated ware	8,717	9,534
Sterling ware	23,717	19,815
Jewelry	12,734	10,995
Photographic materials	46,074	55,530
Dental and medical supplies	1,503	1,942
Mirrors	3,150	4,622
Brazing alloys and solders	13,582	11,198
Electrical and electronic products:		
Batteries	4,253	3,490
Contacts and conductors	27,211	32,329
Bearings	458	273
Catalysts	8,785	12,267
Coins, medallions, commemorative objects	7,186	8,240
Miscellaneous[2]	281	324
Total net industrial consumption	[3]157,650	170,559
Coinage	2,740	1,315
Total consumption	[3]160,390	171,874

[1]End use as reported by converters of refined silver.
[2]Includes silver-bearing copper, silver-bearing lead anodes, ceramics, paints, etc.
[3]Data do not add to total shown because of independent rounding.

Table 10.—Value of silver exported from and imported into the United States

(Thousand dollars)

Year	Exports	Imports
1974	81,651	623,794
1975	147,567	394,536
1976	61,435	378,061

Table 11.—U.S. exports of silver in 1976, by country

(Thousand troy ounces and thousand dollars)

Country	Ore and concentrates		Waste and sweepings		Refined bullion	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	--	--	--	--	75	316
Belgium-Luxembourg	40	120	1,515	6,261	--	--
Brazil	--	--	--	--	350	1,560
Canada	30	127	145	329	662	3,193
France	41	175	10	42	--	--
Germany, West	14	61	169	695	4	15
India	--	--	--	--	3	11
Japan	--	--	1,375	5,831	5,710	24,058
Korea, Republic of	--	--	--	--	16	74
Mexico	--	--	169	665	--	--
Spain	--	--	244	714	122	549
Sweden	--	--	72	341	--	--
Switzerland	32	98	231	978	15	86
Taiwan	--	--	--	--	600	2,548
Tanzania	--	--	19	85	--	--
United Kingdom	(1)	1	2,894	12,325	29	126
Venezuela	--	--	--	--	7	39
Other	--	--	(1)	1	3	11
Total	157	582	6,843	28,267	7,596	32,586

[1]Less than 1/2 unit.

Table 12.—U.S. general imports of silver in 1976, by country

(Thousand troy ounces and thousand dollars)

Country	Ore and concentrates		Waste and sweepings		Doré and precipitates		Refined bullion	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	--	--	--	--	32	135	3	13
Australia	848	3,514	(1)	1	--	--	--	--
Bolivia	49	250	--	--	1	4	--	--
Brazil	--	--	65	240	--	--	--	--
Canada	9,053	38,738	2,767	11,763	187	800	28,559	121,553
Chile	37	147	--	--	199	816	386	1,741
Colombia	48	197	--	--	--	--	--	--
Denmark	82	331	--	--	--	--	--	--
Ecuador	--	--	--	--	--	--	96	403
France	--	--	60	257	--	--	24	98
Guatemala	2	8	--	--	--	--	--	--
Honduras	2,018	8,561	--	--	--	--	217	676
Hong Kong	--	--	45	196	--	--	--	--
India	--	--	20	90	16	70	1,036	4,366
Italy	--	--	3	9	--	--	283	1,241
Japan	--	--	--	--	713	3,056	2,158	9,008
Korea, Republic of	--	--	--	--	16	78	32	130
Mexico	797	3,071	250	1,014	6	2	17,371	75,657
Netherlands	--	--	4	9	--	--	--	--
New Guinea	14	64	--	--	--	--	--	--
New Zealand	--	--	2	4	--	--	--	--
Nicaragua	64	268	--	--	12	49	1	4
Norway	8	35	--	--	--	--	--	--
Panama	--	--	1	4	--	--	2	8
Peru	3,252	13,123	--	--	--	--	8,077	35,104
Philippines	310	1,325	--	--	--	--	--	--
South-West Africa, Territory of	134	579	--	--	--	--	--	--
Trinidad and Tobago	--	--	2	6	--	--	--	--
United Kingdom	--	--	25	98	16	79	5,998	28,389
Venezuela	--	--	7	29	--	--	--	--
Yugoslavia	--	--	--	--	--	--	2,943	10,634
Other	--	--	5	14	--	--	1	12
Total	16,716	70,206	3,256	13,734	1,198	5,089	67,187	289,032

[1]Less than 1/2 unit.

Table 13.—Silver: World production[1] by country

(Thousand troy ounces)

Country[2]	1974	1975	1976[p]
North and Central America:			
Canada	42,810	39,695	40,887
Costa Rica	3	[e]3	[e]2
Dominican Republic	--	[e]109	907
El Salvador	168	176	166
Guatemala	[3]--	[3]--	--
Haiti[e]	20	20	20
Honduras	3,661	3,802	2,964
Mexico	37,546	38,029	42,640
Nicaragua	270	324	204
United States	33,762	34,938	34,328
South America:			
Argentina	[r]3,101	2,283	1,750
Bolivia	[4]5,385	[4]5,470	5,091
Brazil	[r]527	235	[e]250
Chile	[r]6,673	6,263	7,287
Colombia[5]	80	88	106
Ecuador	35	37	52
Peru	[r]34,881	37,527	35,579
Europe:			
Bulgaria[e]	800	800	1,000
Czechoslovakia[e]	[r]1,300	[r]1,200	1,300
Finland	810	744	773
France	[r]1,690	1,502	2,806
Germany, East[e]	3,000	[r]2,100	1,600
Germany, West	1,235	1,079	[e]1,060
Greece[5]	575	480	477
Greenland[e]	390	380	375
Hungary	[e] [r]64	67	[e]70
Ireland[e]	1,980	1,384	925
Italy[5]	1,303	1,157	1,543
Poland[e]	[r]5,800	[r]7,400	8,000
Portugal	24	25	28
Romania[e]	1,100	[r]1,500	1,300
Spain	4,099	3,447	3,107
Sweden	4,545	4,515	[e]4,700
U.S.S.R.[e] [5]	42,000	43,000	44,000
Yugoslavia	4,702	5,412	4,631
Africa:			
Algeria[e]	[r]130	[r]120	150
Kenya	20	--	--
Mauritania	[e]31	[e]26	32
Morocco	3,064	2,894	[e]2,300
Rhodesia, Southern[6]	156	156	103
South Africa, Republic of	2,699	3,084	2,821
South-West Africa, Territory of[7]	[r]1,904	1,823	[e]1,400
Tanzania	([8])	([8])	([8])
Tunisia	136	292	252
Zaire	1,649	2,291	2,472
Zambia[9]	[e] [r]1,100	[e]1,000	1,065
Asia:			
Burma	722	775	211
China, People's Republic of[e]	800	800	800
India[5]	147	83	102
Indonesia	[r]1,138	1,033	1,086
Japan	7,314	8,733	9,299
Korea, North[e]	700	[r]1,600	1,600
Korea, Republic of	[r]1,307	1,494	1,838
Philippines	[r]1,734	1,620	1,481
Taiwan	33	6	1,000
Oceania:			
Australia	[r]21,539	23,449	25,097
Fiji	27	26	20
New Zealand	2	[e]2	1
Papua New Guinea	[r]1,493	1,384	1,841
Total	[r]292,184	297,882	304,899

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Recoverable content of ores and concentrates produced unless otherwise noted.
[2]In addition to the countries listed Ghana, Thailand, and Turkey produce silver, but information is inadequate to make reliable estimates of output levels.
[3]Revised to none.
[4]Includes production by the State mining company (COMIBOL) plus the exports of medium and small (private sector) mines.
[5]Smelter and/or refinery production.
[6]Output by Inyati mine only.
[7]Data include estimate of silver production from Klein Aub Koper Maatskappy Ltd. copper mines.
[8]Less than 1/2 unit.
[9]Refined silver and silver contained in blister copper and refinery muds.

Slag—Iron and Steel

By James R. Evans[1]

Combined sales and usage of iron and steel slags in 1976, at 32.6 million tons, remained fairly constant compared to those of 1975. Total sales value, however, showed about a 10% increase from that of 1975 to $79.7 million— the highest total sales value ever recorded.

During 1976 Vulcan Materials Co. placed an air-cooled iron blast-furnace slag plant onstream in the Chicago area.

DOMESTIC PRODUCTION

Iron slags sold or used in 1976 totaled 26.0 million tons, a slight increase from that of 1975 and near the level of 1970 (fig. 1 and 2). The total sales value for 1976, however, reached $70.0 million—the highest ever recorded. The quantity and sales value of iron slags by major process type are shown in table 1.

Steel slags sold or used in 1976 totaled only 6.6 million tons, the lowest in 7 years. The total sales value, however, of $9.7 million exceeded the 1975 value by $0.8 million.

Slags of all types were processed at 101 major iron and steel furnace slag plants (table 3). There are an undetermined number of smaller plants in the United States that are not shown in table 3. The geographic distribution of slag plants by State is shown in figure 3.

Iron blast-furnace slags were processed in 14 States (table 2). Ohio and Pennsylvania accounted for 46% of the total. Ohio and Pennsylvania plus Illinois, Indiana, and Michigan accounted for 69% of the domestic total.

About 70% of iron slag products in the United States were shipped to markets by truck. Rail shipments composed 26%, and waterway shipments, 4% (table 3). Data for shipments of steel slags were not available.

CONSUMPTION AND USES

Because there were no imports and negligible exports of iron slag products in 1976, production or processing essentially equaled consumption in the United States. As in the past, nearly all of the slag consumed in the United States was in the construction industry.

Iron slag is a waste or byproduct of pig iron production, and the amount of iron slag available each year is controlled by the production of pig iron. It appears that nearly all of the iron slag products made from newly processed material are consumed in the marketplace each year. Steel slags are less available for marketing because each year since 1972 an increasing amount of steel slag has been returned to the blast furnaces as part of the charge. This is done to recover metallic iron. Also, steel slags cannot be used for all purposes for which iron slags are used.

Air-cooled iron blast-furnace slag continued to be the most important slag product in terms of both tons processed and range of applications. Locally, they are competitive with natural aggregates such as crushed stone and sand and gravel. This type of slag shows excellent bonding characteristics when mixed with portland cement to make concrete. It also shows high stability when

[1]Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Iron and steel slags sold or used in the United States, by type[1]

(Thousand short tons and thousand dollars)

Year	Iron blast-furnace slag: Air-cooled: Screened: Quantity	Screened: Value	Air-cooled: Unscreened: Quantity	Unscreened: Value	Granulated: Quantity	Granulated: Value	Expanded: Quantity	Expanded: Value	Total iron slag: Quantity	Total iron slag: Value	Steel slag: Quantity	Steel slag: Value	Total slag: Quantity	Total slag: Value
1970	20,214	40,066	2,038	2,069	1,936	2,134	1,959	6,570	26,147	50,839	7,539	8,832	33,686	59,671
1971	20,217	41,203	1,227	1,149	1,787	2,445	1,581	4,887	24,812	49,684	8,488	9,719	33,300	59,403
1972	20,968	43,652	910	1,135	1,657	3,059	1,518	5,529	25,053	53,375	10,162	11,023	35,215	64,398
1973	23,692	50,737	1,279	1,512	1,999	3,667	1,852	6,936	28,822	62,852	9,739	10,765	38,561	73,617
1974	25,557	56,431	669	796	2,081	4,442	1,573	6,461	29,880	68,130	8,862	11,195	38,742	79,325
1975	21,616	52,442	626	944	1,780	4,335	1,302	5,934	25,324	63,655	7,302	8,965	32,626	72,620
1976	22,312	58,957	587	856	1,618	3,529	1,492	6,610	26,009	69,952	6,588	9,728	32,597	79,680

[1]Value based on selling price at plant.

Source: National Slag Association.

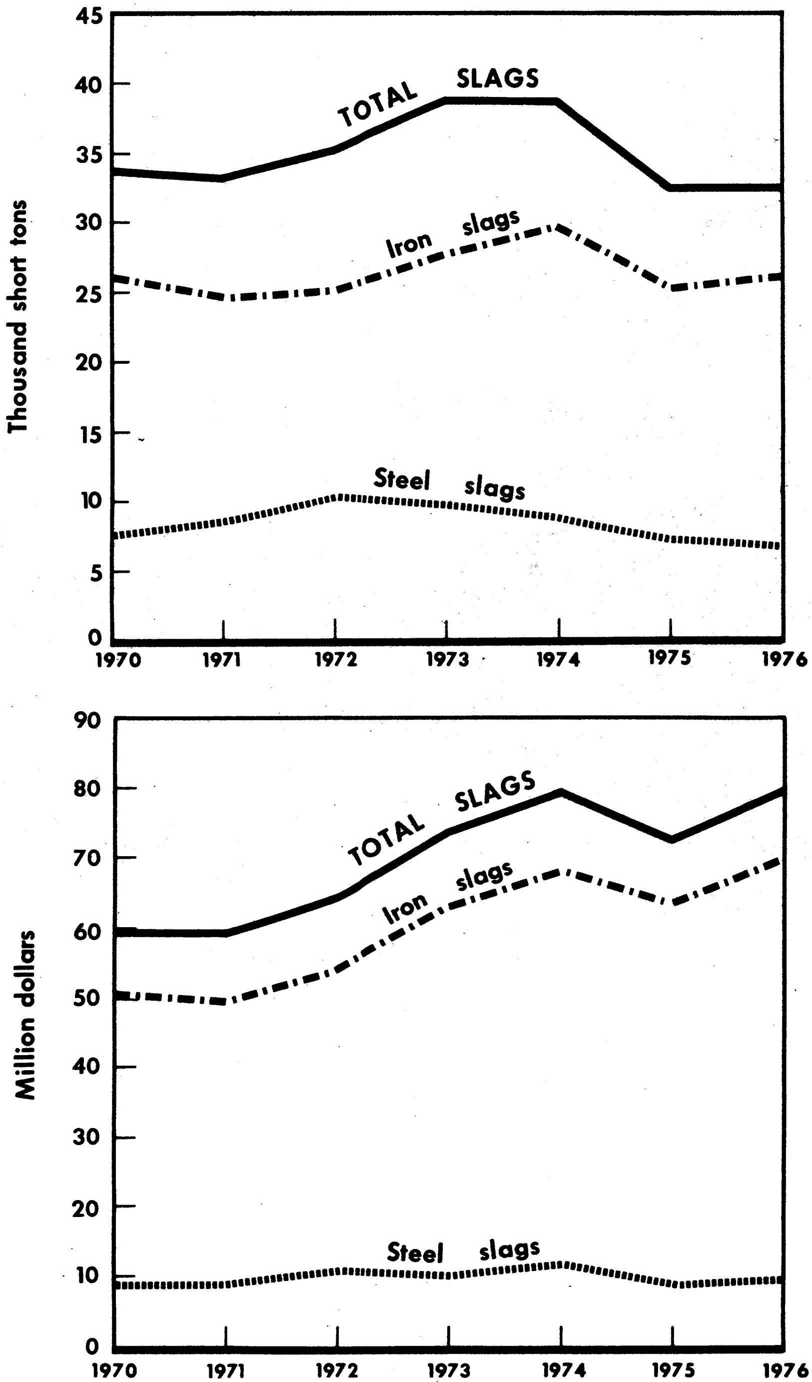

Figure 1.—Quantity and value of iron and steel slags sold or used in the United States.

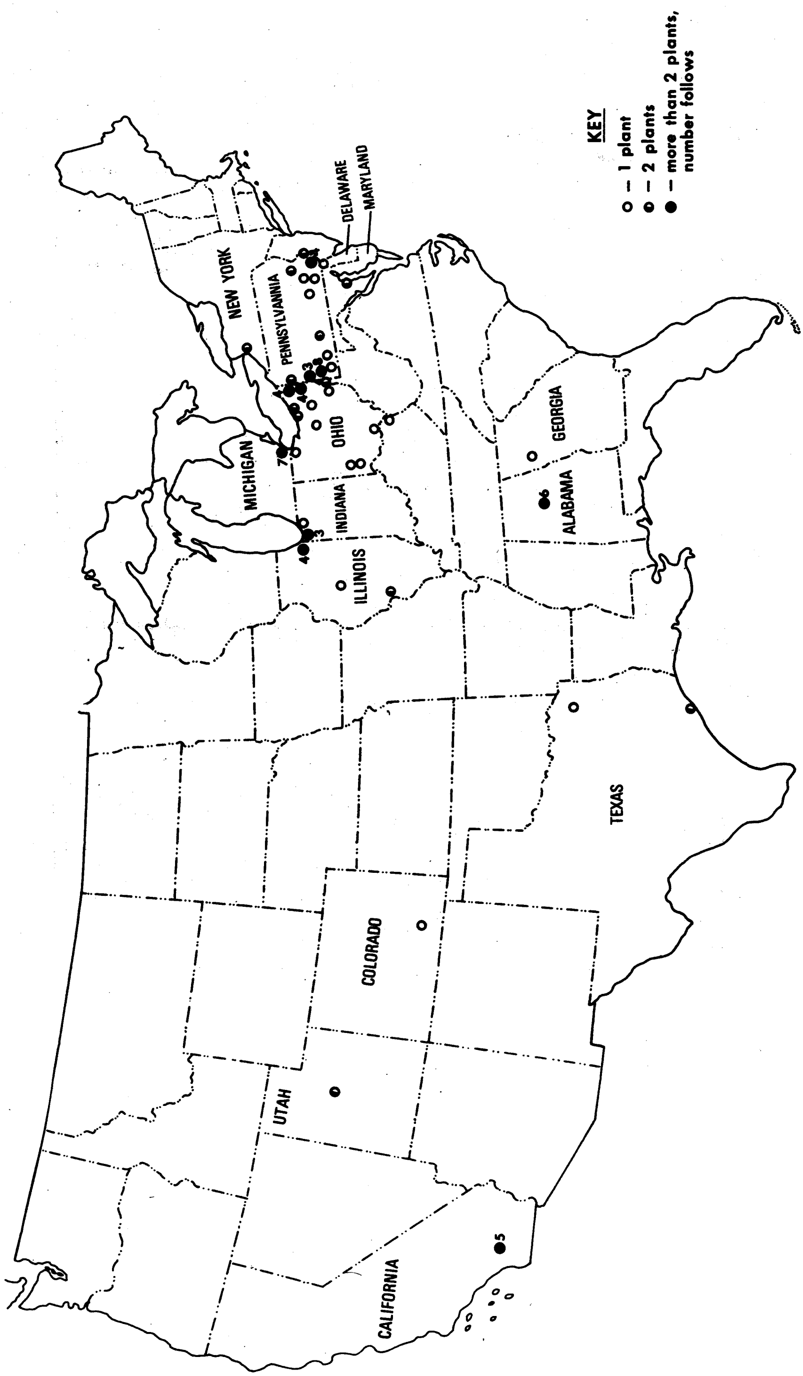

Figure 2.—Location and number of major iron and steel furnace slag plants in the United States.

Table 2.—Iron blast-furnace slags sold or used in the United States, by State[1]

(Thousand short tons and thousand dollars)

Year and State	Screened and air-cooled		All types	
	Quantity	Value	Quantity	Value
1975				
Ohio	4,083	10,487	5,364	13,348
Pennsylvania	4,281	11,042	6,184	17,399
Illinois, Indiana, Michigan	6,046	14,464	5,540	13,638
Other States[2]	7,206	16,449	8,236	19,270
Total	21,616	52,442	25,324	63,655
1976				
Ohio	5,052	13,967	5,792	16,526
Pennsylvania	5,083	14,905	6,075	17,862
Illinois, Indiana, Michigan	5,171	13,979	6,157	17,321
Other States[2]	7,006	16,106	7,985	18,243
Total	22,312	58,957	26,009	69,952

[1]Value based on selling price at plant.
[2]Includes Alabama, California, Colorado, Kentucky, Maryland, New York, Texas, Utah, and West Virginia.

Source: National Slag Association.

used in asphaltic concretes and high skid resistance when used in bituminous road surfacing. Consumption was up slightly from that of 1975 to 22.9 million tons. The use pattern and tonnage by uses were about the same as those in 1975.

Granulated iron-blast furnace slag consumption was down slightly from 1975 to 1.6 million tons (table 6). The major use of granulated slag was in highway construction; consumption was up about 250,000 tons from that of 1975 to 1.2 million tons. Because granulated slag shows natural hydraulic properties, its main use is in highway construction as bases, subbases, and fill. When compacted damp, this type of slag will slowly set into a hard dense mass and assure little overall settlement to pavement or other overlays. Uses other than in highway construction were minor but do show, except for agricultural liming, that consumption in 1976 was down from that of 1975.

Nearly all of the expanded iron-blast furnace slag goes into aggregates for concrete-block manufacture (table 6). This slag is lightweight and shows high fire resistance and low shrinkage properties, which makes it very desirable for lightweight concrete blocks. Consumption for this use was up about 300,000 tons from that of 1975 to 1.4 million tons.

Steel slags are used mainly for unconfined bases, fill, and highway shoulders (table 7). Because steel slags can exhibit uncontrolled expansion, a result of hydration of free lime, and marked variations in chemical composition and physical properties, uses for steel slags are limited. Aging for a period of at least 6 months has proved useful in controlling expansion. In 1976 total consumption was down about 700,000 tons from that of 1975 to 6.6 million tons.

Table 3.—Major iron and steel furnace slag plants and sources in the United States[1]

State and City	Company	Iron slag: Air-cooled	Iron slag: Expanded	Iron slag: Granulated	Steel slag: Open hearth	Steel slag: Basic oxygen process	Steel slag: Electric
Alabama:							
Alabama City	Vulcan Materials Co	X	--	--	--	X	--
Birmingham	U. S. Pipe and Foundry Co.	X	--	--	--	--	--
Ensley	Vulcan Materials Co	X	--	--	--	--	--
Fairfield	Do	X	--	--	--	--	--
Total		4	--	--	--	1	--
California:							
Fontana	Heckett Co	X	--	--	X	X	--
Montebello	Do	--	--	--	--	--	X
Tarrance	Do	--	--	--	--	--	X
Total		1	--	--	1	1	2
Colorado:							
Pueblo	Fountain Sand and Gravel Co	X	--	--	--	--	--
Do	International Mill Service	--	--	--	--	X	X
Total		1	--	--	--	1	1
Delaware:							
Claymont	International Mill Service	--	--	--	--	--	X
Total		--	--	--	--	--	1
Georgia:							
Atlanta	International Mill Service	--	--	--	--	--	--
Total		--	--	--	--	--	1
Illinois:							
Bartonville	International Mill Service	--	--	--	--	--	X
Chicago	Illinois Slag & Ballast Co	X	--	--	--	X	--
Do	United States Steel Corp	--	--	--	--	X	--
Granite City	International Mill Service	--	--	--	--	X	--
Do	St. Louis Slag Products, Co., Inc	X	--	--	--	--	--
Total		2	--	--	--	3	1

Table 5.—Major iron and steel furnace slag plants and sources in the United States[1] —Continued

State and City	Company	Iron slag			Steel slag		
		Air-cooled	Expanded	Granulated	Open hearth	Basic oxygen process	Electric
Pennsylvania:							
Belle Vernon	Duquesne Slag Products Co	X	--	--	--	--	--
Bethlehem	Sheridan Slag Co	--	X	--	--	--	--
Do	Bethlehem Steel Corp	X	--	--	--	--	--
Birdsboro	Birdsboro Slag Products	X	--	--	--	--	--
Coatsville	International Mill Service	--	--	--	--	--	X
Conshohocken	Sheridan Corp	X	X	--	--	X	--
Johnstown	Standard Slag Co	X	--	--	X	--	--
Lebanon	Sheridan Corp	X	--	--	--	--	--
Midland	International Mill Service	X	--	--	--	X	X
Morrisville	Warner Co	X	--	--	X	--	--
Pittsburgh	Duquesne Slag Products Co	X	--	X	--	--	--
Do	United States Steel Corp	--	--	X	X	X	--
Phoenixville	International Mill Service	--	--	--	X	--	--
Pricedale	Duquesne Slag Products Co	--	--	X	--	--	--
Sharpsville	Sharpsville Steel Co	X	--	--	X	--	--
Vanderbilt	Vanderbilt Slag Co	--	--	X	--	--	--
West Aliquippa	Duquesne Slag Products Co	X	--	--	--	--	--
West Miflin	Do	X	--	--	--	--	--
Total		12	2	4	5	8	2
Texas:							
Daingerfield	Gifford-Hill Co	X	--	--	--	--	X
Houston	Houston Slag Materials Co	X	--	--	--	--	X
Total		2	--	--	--	--	1
Virginia:							
Virginia Beach	Maryland Slag Co	S	S	--	--	--	--
Total		1	1	--	--	--	--
Utah:							
Provo	United States Steel Corp	X	--	--	X	--	--
Total		1	--	--	1	--	--
West Virginia:							
Weirton	International Mill Service	--	--	--	--	X	--
Do	Standard Slag Co	X	--	--	--	--	--
Total		1	--	--	--	1	--
Grand total		48	11	7	9	16	10

[1]X-represents plants; S-represents sources.
[2]Basic oxygen process, air-cooled blend.

Table 4.—Shipments of iron slag in the United States, by method of transportation

Method of transportation	1975 Thousand short tons	1975 Percent of total	1976 Thousand short tons	1976 Percent of total
Rail	6,129	24	6,648	26
Truck	18,142	72	18,240	70
Waterway	1,053	4	1,121	4
Total	25,324	100	26,009	100

Source: National Slag Association.

Table 5.—Air-cooled iron blast-furnace slag sold or used in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1975				1976			
	Screened		Unscreened		Screened		Unscreened	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Aggregate in—								
Portland cement concrete construction	1,620	4,572	--	--	1,928	5,733	--	--
Bituminous construction (all types)	3,396	8,911	--	--	4,060	11,388	--	--
Highway and airport construction[2]	10,504	25,516	539	847	10,188	27,333	546	809
Manufacture of concrete block	343	1,007	--	--	298	921	--	--
Railroad ballast	4,029	7,490	6	13	3,790	7,715	--	--
Mineral wool	589	1,848	--	--	758	2,236	--	--
Roofing slag:								
Cover material	232	1,072	--	--	208	745	--	--
Granules	6	21	--	--	13	58	--	--
Sewage trickling filter medium	29	47	--	--	12	66	--	--
Agricultural slag, liming	2	3	--	--	61	203	--	--
Other uses	866	1,955	81	84	1,046	2,564	41	47
Total	21,616	52,442	626	944	22,312	58,957	587	856

[1]Value based on selling price at plant.
[2]Other than in portland cement concrete and bituminous construction.

Source: National Slag Association.

Table 6.—Granulated and expanded iron blast-furnace slags sold or used in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1975				1976			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Highway construction and fill (road, etc.)	959	2,032	--	--	1,199	2,332	--	--
Agriculture slag, liming	52	129	--	--	59	168	--	--
Manufacture of cement (all types)	228	1,201	--	--	87	334	--	--
Lightweight concrete	--	--	162	841	--	--	9	47
Aggregate for concrete-block manufacture	230	429	1,092	4,976	125	454	1,398	6,382
Other uses	311	544	48	117	148	241	85	181
Total	1,780	4,335	1,302	5,934	1,618	3,529	1,492	6,610

[1]Value based on selling price at plant.

Source: National Slag Association.

Indiana:							
Burns Harbor	The Levy Co	X	--	--	--	[2]X	--
Gary	United States Steel Corp	X	X	--	--	X	--
Indiana Harbor	Vulcan Materials Co	X	--	--	--	--	--
Total		3	1	--	--	2	--
Kentucky:							
Ashland	Standard Slag Co	X	--	--	--	--	--
Total		1	--	--	--	--	--
Maryland:							
Baltimore	Maryland Slag Co	X	X	--	--	--	--
Easton	Do	S	S	--	--	--	--
Pocomoke	Do	S	S	--	--	--	--
Salisbury	Do	S	S	--	--	--	--
Total		4	4	--	--	--	--
Michigan:							
Detroit	E. C. Levy Co	X	X	X	--	X	--
Ecarse	Do	--	--	--	--	X	--
Trenton	Do	X	--	--	--	X	--
Total		2	1	1	--	3	--
New York:							
Buffalo	Buffalo Slag Co	X	X	--	--	--	--
Total		1	1	--	--	--	--
Ohio:							
Canton	Republic Steel Co	X	--	--	--	--	--
Cleveland	Standard Slag Co	X	--	--	--	X	--
Hamilton	American Materials Corp	X	--	--	--	--	--
Lorain	United States Steel Corp	X	--	--	X	--	--
Mansfield	International Mill Service	--	--	--	--	--	X
Middletown	American Materials Corp	X	--	--	--	--	--
Lordstown	Standard Slag Co	X	X	X	--	--	--
Mingo Junction	Do	X	--	--	--	--	--
Portsmouth	Do	X	--	--	--	--	--
Struthers	Do	--	--	X	--	--	--
Toledo	France Stone Co	X	--	--	--	--	--
Warren	Standard Slag Co	X	--	--	--	--	--
Youngstown	Do	X	--	--	--	--	--
Do	United States Steel Corp	X	--	--	X	--	--
Total		12	1	2	2	1	1

See footnotes at end of table.

Table 7.—Steel slag sold or used in the United States, by use[1] [2]

(Thousand short tons and thousand dollars)

Use	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Railroad ballast	613	745	465	640
Highway base or shoulders	2,701	3,239	2,376	3,529
Paved-area base	1,514	2,201	1,713	2,592
Miscellaneous base or fill	1,947	2,233	1,412	2,081
Bituminous mixes	280	313	353	510
Agricultural	--	--	--	--
Other uses	247	234	269	376
Total	7,302	8,965	6,588	9,728

[1]Excludes tonnage returned to furnace for charge material.
[2]Value based on selling price at plant.

Source: National Slag Association.

PRICES

Average selling prices of slags at the plant for all major uses were higher in 1976. The average prices given in table 8 were derived from the total values and quantities shown in tables 5, 6, and 7. Data given in the range column of table 8 reflect the highest and lowest known selling prices of material that went into the use categories. Extreme higher prices in the use categories indicate that some users required demanding specifications, which necessitated more than normal processing. In some geographic areas overall construction as well as other costs are higher, resulting in higher prices for processed materials.

FOREIGN TRADE

There were no known imports of slags in 1976. Approximately 46,000 tons of iron blast-furnace slag were exported to Canada from the Buffalo, N.Y., and Detroit, Mich., areas.

WORLD REVIEW

The steel industry in Japan generated about 40 million tons of slag in 1976, which created environmental and disposal problems.[2] Nihon Cement Co. and the second ranked steel producer in Japan, Nippon Kokan, began a study on the possibility of using slag in cement and/or concrete aggregates. The study should be completed in 1977.

TECHNOLOGY

Fourteen technical papers on slag were presented in the October 1976 at the International Slag Conference at Mons, France. A wide variety of subject matter was treated, including blast furnace slags in vitroceramics, steel slag application in highway construction, relation between strength of slag cement and properties of slag, and studies of ferroalloy slags.

Laboratory studies on the use of fine-grained, self-cementing pelletized blast furnace slag in stabilized base construction were conducted at McMaster University, Hamilton, Ontario, Canada.[3] The finer portions of the minus 200-mesh portion of the ground pelletized slag showed cementing properties, and a satisfactory base mix of 70% crusher run slag and 30% ground pellets was developed. It was reported that ground pelletized blast furnace slag can offer, in many cases, a viable alternative to the use of asphaltic or portland cements, with an attendant saving in energy.

[2]Rock Products. Newscope. V. 79, No. 6, 1976, p. 18.
[3]Emery, J. J., C. S. Kim, and R. P. Cotsworth. Base Stabilization Using Pelletized Blast Furnace Slag. J. Test. and Eval., V. 4, No. 1, American Society for Testing and Materials, 1976, pp. 94-100.

Table 8.—Average value and range of values of iron and steel slags sold in the United States, by use, in 1976[1]

(Per short ton)

Use	Iron blast-furnace slag								Steel slag	
	Air cooled									
	Screened		Unscreened		Granulated		Expanded			
	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Aggregate in										
Portland cement concrete construction	$2.97	$2.02-3.13	--	--	$3.84	$3.50-$4.50	--	--	--	--
Bituminous construction (all types)	2.80	2.02-5.26	--	--	--	--	--	--	$1.44	$1.25-1.57
Highway and airport construction[2]	2.70	1.82-3.30	$1.48	$0.81-1.90	1.95	1.50-2.20	--	--	1.49	0.53-2.43
Manufacture of concrete block	3.09	2.40-4.10	--	--	3.63	3.59-5.62	$4.56	$2.50-6.00	--	--
Lightweight concrete	--	--	--	--	--	--	5.23	3.16-7.00	--	--
Railroad ballast	2.04	1.13-4.38	--	--	--	--	--	--	1.38	0.49-2.70
Mineral wool	2.95	2.00-3.42	--	--	--	--	--	--	--	--
Roofing slag:										
Cover material	3.58	2.11-4.33	--	--	--	--	--	--	--	--
Granules	4.08	3.39-4.50	--	--	--	--	--	--	--	--
Sewage trickling filter medium	5.50	3.10-9.22	--	--	--	--	--	--	--	--
Agricultural slag, liming	3.33	2.00-3.37	--	--	2.85	2.15-2.86	--	--	--	--
Other uses	2.45	1.85-10.47	1.15	1.13-1.70	1.64	1.56-3.80	2.13	--	1.40	0.42-2.99

[1]Average value based on selling price at plant, range of values represent selling price per ton at plant.
[2]Other than in portland cement and bituminous construction.

Source: National Slag Association.

Sodium and Sodium Compounds

By Russell J. Foster[1]

The general economic upturn in 1976 prompted increased production in the chemical, glass, and pulp and paper industries, resulting in greater consumption of sodium compounds compared with the amounts used in 1975. The quantity and value of sodium compounds and metallic sodium produced in 1976 follow:

	Production (thousand short tons)	Value (thousand dollars)
Soda ash	5,216	259,253
Sodium sulfate	663	32,655
Metallic sodium	146	[e]71,754

[e]Estimate.

Natural soda ash production increased 21%, but output of synthetic material decreased 16%. One Solvay soda ash plant closed in 1976, but a new natural facility came onstream, and two other producers of natural ash were in the process of adding capacity. Production of both natural and synthetic sodium sulfate remained virtually unchanged. One producer of natural sodium sulfate had an expansion under construction. Exports of soda ash reached 9% of production. Net sodium sulfate imports totaled 17% of apparent consumption.

DOMESTIC PRODUCTION

The total amount of soda ash produced in 1976 was 7,560,000 tons, a 6% increase over that of 1975. Production of natural soda ash derived from trona or brine increased 21%, but synthetic ash declined 16%. The natural material claimed 69% of total production. Table 2 illustrates the continuing trend away from Solvay, toward natural ash.

[1]Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Manufactured and natural sodium carbonates produced in the United States

(Thousand short tons and thousand dollars)

Year	Manufactured soda ash (ammonia-soda process)[1] [2]	Natural sodium carbonates[3]		Total quantity
	Quantity	Quantity	Value	
1972	4,305	3,218	71,689	7,523
1973	3,813	3,722	94,385	7,535
1974	3,507	4,059	137,486	7,566
1975	2,802	4,328	182,620	7,130
1976	2,344	5,216	259,253	7,560

[1]Current Industrial Reports, Inorganic Chemicals, U.S. Bureau of the Census.
[2]Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.
[3]Soda ash and trona (sesquicarbonate).

Table 2.—Source of U.S. soda ash by process, 1967-76

(Thousand short tons)

Year	Solvay		Natural	
	Production	Percent of total	Production	Percent of total
1967	4,849	73.7	1,726	26.3
1968	4,596	69.2	2,043	30.8
1969	4,540	64.5	2,495	35.5
1970	4,393	62.1	2,678	37.9
1971	4,298	60.0	2,865	40.0
1972	4,305	57.2	3,218	42.8
1973	3,813	50.6	3,722	49.4
1974	3,507	46.4	4,059	53.6
1975	2,802	39.3	4,328	60.7
1976	2,344	31.0	5,216	69.0

Diamond Shamrock closed its 800,000-ton-per-year synthetic soda ash plant at Painesville, Ohio, at yearend 1976. Only three synthetic plants with a total capacity of about 2 million tons remain in the United States—Allied Chemical Corp. at Syracuse, N.Y., BASF-Wyandotte at Wyandotte, Mich., and PPG Industries at Corpus Christi, Tex.[2]

Texasgulf, Inc., became the fifth producer of natural soda ash in the United States when its 1-million-ton-per-year operation came onstream at Granger, Wyo., in October 1976. The capacity of the $150 million, coal-fired facility reportedly can be doubled with a minimum of inconvenience.[3]

The completion of a 750,000-ton-per-year expansion project at yearend 1975 brought the capacity of FMC Corp.'s natural soda ash plant in Wyoming up to 2.5 million tons per year.[4] Stauffer Chemical Co. was enlarging the capacity of its Wyoming plant by 200,000 tons per year. Completion was scheduled for early 1977.[5] Construction continued on the expansion of Kerr-McGee Chemical Corp.'s soda ash plant at Trona, Calif. The project will raise the capacity to 1.3 million tons per year by February, 1978. The boilers of the new facility were designed to burn solid, gaseous, or liquid fuels.[6]

Total production of sodium sulfate in 1976 was 1,232,000 tons. Production of both natural and byproduct material was essentially unchanged from that of the previous year. Nearly 54% of the total sodium sulfate was the natural compound, produced by three companies operating five plants in California, Texas, and Utah. Kerr-McGee Chemical Corp. was increasing natural sodium sulfate capacity by 150,000 tons per year at Trona, Calif., with startup slated for February, 1978.[7]

[2]Chemical and Engineering News. Another Big Synthetic Soda Ash Plant Will Close. V. 54, No. 25, June 14, 1976, p. 10.
Chemical Week. Bowing Out of Soda Ash. V. 118, No. 24, June 16, 1976, p. 21.

[3]Chemical Marketing Reporter. Texasgulf Starts Output of Soda Ash in Wyoming. V. 210, No. 15, Oct. 11, 1976, pp. 7, 31.

[4]———. FMC Soda Ash Facility Completed at Green River. V. 209, No. 13, Mar. 29, 1976, pp. 3, 21.

[5]Chemical Week. In Alkali Battle, Five Bet on the Underdog. V. 119, No. 18, Nov. 3, 1976, pp. 14-15.

[6]Chemical Marketing Reporter. Kerr-McGee Tops Out Soda Ash Skyscraper. V. 210, No. 6, Aug. 9, 1976, pp. 7, 25.

[7]Chemical Week. Kerr-McGee Going Ahead With Major Expansion. V. 117, No. 10, Sept. 3, 1975, p. 9.

Table 3.—Sodium sulfate produced in the United States[1]

(Thousand short tons and thousand dollars)

Year	Manufactured and natural[2]			Natural only	
	Lower purity[3] (99% or less)	High purity	Total quantity	Quantity	Value
1972	526	801	1,327	701	11,396
1973	530	r908	1,438	672	11,597
1974	565	783	1,348	684	16,411
1975	431	796	1,227	667	27,667
1976	466	766	1,232	663	32,655

rRevised.
[1]All quantities converted to 100% Na_2SO_4 basis.
[2]Current Industrial Reports, Inorganic Chemicals, U.S. Bureau of the Census.
[3]Includes Glauber's salt.

Metallic sodium production increased about 1% to 145,863 tons. Table 4 shows the production and price trends of metallic sodium over the past 10 years.

A list of U.S. producers of natural sodium compounds and metallic sodium follows:

Product and company	Plant location	Source of sodium
Soda ash:		
Kerr-McGee Chemical Corp	Trona, Calif	Dry lake brine.
Do	Westend, Calif	Do.
Allied Chemical Corp	Green River, Wyo	Underground trona.
FMC Corp	do	Do.
Stauffer Chemical Co	do	Do.
Texasgulf, Inc	Granger, Wyo	Do.
Sodium sulfate:		
Kerr-McGee Chemical Corp	Trona, Calif	Dry lake brine.
Do	Westend, Calif	Do.
Ozark-Mahoning Co	Brownfield, Tex	Subterranean brine.
Do	Seagraves, Tex	Do.
Great Salt Lake Minerals & Chemical Corp.	Ogden, Utah	Salt lake brine.
Metallic sodium:		
E. I. du Pont de Nemours & Co	Niagara Falls, N. Y	Salt.
Do	Memphis, Tenn	Do.
Ethyl Corp	Baton Rouge, La	Do.
Do	Houston, Tex	Do.
R. M. I., Inc	Ashtabula, Ohio	Do.

Table 4.—Production and price of metallic sodium in the United States, 1967-76

Year	Production (short tons)	Price (cents per pound)
1967	164,528	15.36
1968	156,391	15.47
1969	164,685	15.84
1970	171,251	15.94
1971	153,075	16.26
1972	160,504	16.98
1973	176,903	17.43
1974	173,174	17.89
1975	[r]144,133	20.70
1976	145,863	[e]24.60

[e]Estimate. [r]Revised.

CONSUMPTION AND USES

Estimated industrial demand for soda ash and sodium sulfate is tabulated below:[8]

Industry	Percent of demand	
	Soda ash	Sodium sulfate
Pulp and paper	7	70
Glass	47	--
Detergents	6	20
Chemicals	25	--
Water treatment	3	--
Other and exports	12	10

Apparent consumption of sodium carbonate and sodium sulfate rose in 1976, reflecting recovery from the 1975 economic slump. Total production of chemicals and related products increased. Greater demand for chlorine made coproduct caustic soda increasingly available to compete with soda ash in certain processes.

The glass industry exhibited growth in all major areas— containers, fibers, and especially flat glass. Production of pulp, paper, and board products rose 9% to 14%. Increased demand for gasoline antiknock additives contributed to a 1% increase in metallic sodium production.

[8]Chemical Marketing Reporter. Sodium Sulfate. V. 207, No. 8, Feb. 24, 1975, p. 9.
———. Soda Ash. V. 208, No. 8, Aug. 25, 1975, p. 9.

PRICES

The prices of natural soda ash and natural sodium sulfate, f.o.b. mine or plant, as reported by producers were as follows:

	Value, dollars per short ton		Change, percent
	1975	1976	
Bulk soda ash	42.20	49.70	+18
Bulk sodium sulfate	41.48	49.25	+19

Yearend prices of metallic sodium and sodium compounds quoted by Chemical Marketing Reporter follow:

		1975[1]	1976[1]
Sodium carbonate (soda ash):			
Light, paper bags, carlots, works	per ton	\$57.00 -71.00	\$57.00 -71.00
Light, bulk, carlots, works	do	57.00 -64.00	57.00 -64.00
Dense, paper bags, carlots, works	do	57.00 -71.00	57.00 -71.00
Dense, bulk, carlots, works	do	47.00 -49.00	47.00 -49.00
Sodium sulfate (100% Na_2SO_4):			
Technical detergent, rayon-grade, bags, carlots	do	60.00 -65.00	70.00 -72.00
Technical detergent, rayon-grade, bulk, works	do	55.00	55.00
Domestic salt cake, bulk, works[2]	do	60.00	60.00
National Formulary (N.F. XII), drums	per pound	.235	.235
Metallic sodium:			
Bricks, carlots, works	do	.30	.29
Fused, lots 18,000 pounds and more, works	do	.265- .275	.265- .29
Bulk, tank, works	do	.225	.225

[1]Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 208, No. 26, Dec. 29, 1975; V. 210, No. 26, Dec. 27, 1976.
[2]East of Mississippi River.

FOREIGN TRADE

In 1976 U.S. exports of soda ash reached 645,000 tons, or 9% of total production, and imports were negligible. More than 36% of the exported soda ash went to other countries in North America, 30% to South America, 23% to Asia and Oceania, and 11% to Africa.

Imports of sodium sulfate amounted to 316,000 tons. Half of the imported material came from Canada, and 44% was shipped from Belgium. Sodium sulfate exports totaled 57,000 tons, or 5% of production. The principal destinations for exported sodium sulfate were Oceania, 57%, and Canada, 33%. The total value of exported sodium compounds exceeded the value of imports by over \$37 million.

Table 5.—U.S. exports of sodium carbonate and sodium sulfate

(Thousand short tons and thousand dollars)

Year	Sodium carbonate		Sodium sulfate	
	Quantity	Value	Quantity	Value
1974	564	34,156	51	3,250
1975	r529	r45,822	77	6,144
1976	645	49,781	57	3,636

rRevised.

Table 6.—U.S. imports for consumption of sodium sulfate

(Thousand short tons and thousand dollars)

Year	Crude (salt cake)[1]		Anhydrous		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1974	277	7,162	98	3,220	375	10,382
1975	203	8,305	82	4,319	285	12,624
1976	214	10,360	102	5,751	316	16,111

[1]Includes Glauber's salt as follows: 1974, 1,270 short tons ($29,166); 1975 and 1976, none.

Table 7.—U.S. imports for consumption of sodium carbonate and bicarbonate in 1976

(Thousand short tons and thousand dollars)

	Quantity	Value
Soda ash	(1)	2
Sodium bicarbonate	2	153
Total	2	155

[1]Less than 1/2 unit.

WORLD REVIEW

World production of soda ash and sodium sulfate, by country, is listed in tables 8 and 9. Only 22% of the world's soda ash was derived from natural sources in 1976, and the United States produced 98% of that quantity. The five top-ranking nations in the production of soda ash were the United States, the U.S.S.R., West Germany, France, and Japan.

Natural sodium sulfate provided 50% of the world's supply, and the United States and Canada combined produced 56% of the natural material. The top five sodium sulfate producing countries in the world were the United States, the U.S.S.R., Canada, Japan, and Spain.

Bulgaria.—Plans were announced for increasing the capacity of the mineral fertilizer and soda ash plant at Devnya.[9]

Colombia.—The state-owned Cia. Colombiana de Alcalis revealed plans for a $12 million expansion of its 308,000-ton-per-year soda ash production facilities.[10]

India.—By 1979-80 India expects to increase production of soda ash to nearly 1.2 million tons per year. This will be accomplished by commissioning three new units at Tarapore, Haldia and Tuticorin, and the expansion of two existing plants at Mithapur and Porbandar.[11]

United Kingdom.—Imperial Chemical Industries, Ltd., allotted a total of $30 million over the next 2 years to modernize its synthetic soda ash complex in Cheshire. An extra 8,000 tons of capacity is scheduled, which would bring ICI Mond Div.'s soda ash capacity in the United Kingdom to about 1,925,000 tons per year.[12]

[9]Industrial Minerals. Company News & Mineral Notes. No. 110, November, 1976, p. 44.

[10]———. Company News & Mineral Notes. No. 101, February, 1976, p. 50.

[11]Work cited in footnote 9.

[12]Chemical Marketing Reporter. ICI Spends $20 Million on Soda Ash Facilities. V. 210, No. 20, Nov. 15, 1976, pp. 3, 38.

Table 8.—Sodium carbonate: World production by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
Natural:			
Chad	6	6	[e]6
Kenya	[r]172	101	127
United States	4,059	4,328	5,216
Total	[r]4,237	4,435	5,349
Manufactured[e]:			
Albania[e]	23	23	23
Belgium	444	386	[e]430
Brazil	140	140	150
Bulgaria	707	1,090	[e]1,090
Chile[e]	11	9	10
Colombia[e]	[r]45	45	55
Czechoslovakia	[r]134	133	[e]138
Denmark[2]	1	1	1
France	[r]1,724	1,409	1,451
Germany, East	886	902	[e]910
Germany, West	1,605	1,377	1,503
Greece	([3])	[e]1	[e]1
India	562	594	621
Italy[e]	794	730	760
Japan	1,463	1,239	1,197
Korea, Republic of	107	140	171
Mexico	444	450	[e]450
Netherlands	326	244	299
Norway	23	21	[e]23
Pakistan	89	87	70
Poland	[r]787	788	[e]795
Portugal	149	127	126
Romania	890	764	[e]830
Spain	531	521	[e]535
Sweden[e]	1	1	1
U.S.S.R.	4,943	5,172	[e]5,235
United States	3,507	2,802	2,344
Yugoslavia	157	162	151
Total	[r]20,495	19,358	19,370

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, a number of nations are either known or believed to have produced sodium carbonate, but production is unreported, and available general information is inadequate for the formulation of reliable estimates of output levels.

[2]Production for sale only; excludes output consumed by producers.

[3]Less than 1/2 unit.

Table 9.—Sodium sulfate: World production by country

(Thousand short tons)

Country[1]	1974	1975	1976[p]
Natural:			
Argentina	[r]42	43	[e]44
Canada	703	521	540
Chile[2]	10	13	14
Iran	28	28	28
Mexico	163	331	251
Spain	142	152	[e]154
Turkey	61	89	97
U.S.S.R.[e 3]	310	330	350
United States	684	667	663
Total	[r]2,143	2,174	2,141
Manufactured:			
Chile[4]	[r]34	25	31
France	[r]181	162	143
Germany, East	216	214	[e]215
Germany, West	309	283	283
Greece	7	[e]7	[e]7
Hungary[e]	11	11	11
Italy	115	110	[e]117
Japan	418	324	345
Portugal	[r]55	57	54
Spain[5]	[r]182	154	[e]165
U.S.S.R.[e 3]	220	230	240
United States[6]	664	560	569
Total	[r]2,412	2,137	2,180

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, the People's Republic of China, Poland, Romania, and the United Kingdom are assumed to have produced manufactured sodium sulfate, and other unlisted countries may have produced this commodity, but production figures are not reported and available general information is inadequate for the formulation of reliable estimates of output levels.

[2]Natural mine output, excluding byproduct output from the nitrate industry, which is reported separately under manufactured.

[3]Conjectural estimates based on 1968 information on natural sodium sulfate and general economic conditions.

[4]Byproduct of nitrate industry.

[5]Quantities of manufactured sodium sulfate credited to Spain are reported in official sources in such a way as to indicate that they are in addition to the quantities reported as mined (reported in this table under natural), but some duplication may exist.

[6]Derived figure; data presented are the difference between reported total sodium sulfate production (natural and manufactured, undifferentiated) and reported natural sodium sulfate production (reported under natural in this table).

TECHNOLOGY

The need for conservation of energy resources has prompted increased funding for battery systems that weigh less and store more energy than present models, and that can compete with gasoline power on a cost basis. Among the high-storage-density batteries currently under development is the molten sodium-sulfur system, which consists of a reservoir of molten sodium metal separated from a supply of molten sulfur by a solid electrolyte that conducts sodium ions. The system has a very high energy density and operates at 300° to 350°C. What makes the sodium-sulfur batteries attractive for electric vehicles is their low potential cost and lower operating temperatures than competitive lithium versions.[13]

The Superior Oil Co. reportedly has perfected a multimineral process to extract soda ash, nahcolite (sodium bicarbonate), alumina, and oil from deposits containing oil shale, nahcolite, and dawsonite in Colorado's Piceance Basin. The modular plant separates nahcolite from the shale by friability difference, and recovers oil by use of a circular-grate retort. Dawsonite and any remaining nahcolite are dissolved in alkali to yield a solution of sodium aluminate and sodium carbonate. Aluminum hydroxide is crystallized, filtered, and calcined into cell-grade alumina. Sodium carbonate is recovered using triple-effect evaporation and centrifugation. Spent shale is returned to the mine.[14]

[13]Chemical Week. New Batteries Are in the Running. V. 119, No. 22, Dec. 1, 1976, pp. 31-37.

[14]Engineering and Mining Journal. This Month in Mining. News Briefs. V. 177, No. 7, July 1976, p. 125.

Chemical and Engineering News. Prognosis Good for New Shale Oil Process. V. 55, No. 2, Jan. 10, 1977, pp. 27-28.

Stone

By Avery H. Reed[1]

The stone industry leveled off and operated at about the same rate as in 1975. Output of dimension stone was 1.40 million tons valued at $104.4 million, 27% below 1974 production. Output of crushed stone was 900 million tons valued at $2.12 billion, 15% below the 1973 record production.

Stone was produced in every State except Delaware and North Dakota. There were 2,188 companies, operating 5,665 quarries. Average output per company was 412,000 tons. Average output per quarry was 159,000 tons. More than half the stone was produced at quarries producing more than 500,000 tons each. Most of the stone was hauled by truck.

Leading stone producers were Vulcan Materials Co., 86 quarries, Martin Marietta Corp., 112 quarries; United States Steel Corp., 14 quarries; Medusa Corp., 50 quarries; Koppers Co., 45 quarries; Lone Star Industries, Inc., 24 quarries; U.S. Forest Service, 534 quarries; General Dynamics Corp., 7 quarries; Ashland Oil Corp., 34 quarries; and the Flintkot Co., 20 quarries. With 926 quarries, these 10 operators accounted for 24% of the total production of stone.

Classification.—The Bureau of Mines classifies stone into two categories (crushed and dimension) and into nine kinds (granite, limestone, marble, marl, sandstone, shell, slate, traprock, and miscellaneous).

The category classifications are not exact; some crushed stone may be in large pieces, such as riprap, and some dimension stone may be in small pieces, such as art objects or carvings. The dimension stone industry is concerned with cutting or shaping stone to a certain size, and waste or scrap from processing dimension stone may be a part of the crushed stone industry.

Classification by kind is also difficult. Granite may include metamorphic gneisses or syenites. Limestone may be pure calcium carbonate, but may be bituminous, dolomitic, or siliceous. Marble may include any calcareous rock that will polish. Marl may range from low to high in shale or clay content. Sandstone may be calcareous, quartz or quartzite, silt, or conglomerate. Miscellaneous stone includes aa, lava, schist, and any other stone not included in the aforementioned categories.

[1]Supervisory physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient stone statistics in the United States

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
Sold or used by producers:					
Dimension stone	1,490	1,582	1,915	1,403	1,400
Value	$90,763	$85,999	$100,318	$98,586	$104,400
Crushed stone	918,933	1,058,541	1,041,600	r899,990	900,260
Value	$1,581,530	$1,904,464	$2,085,800	r$2,021,700	$2,116,600
Total stone	920,423	[1]1,060,124	1,043,515	r901,390	901,660
Value	$1,672,293	$1,990,463	$2,186,118	r$2,120,300	$2,221,000
Exports (value)	$11,107	$13,063	$18,159	$22,125	$23,965
Imports for consumption (value)	$43,436	$48,678	$51,631	$46,137	$46,211

rRevised.
[1]Data may not add to totals shown because of independent rounding.

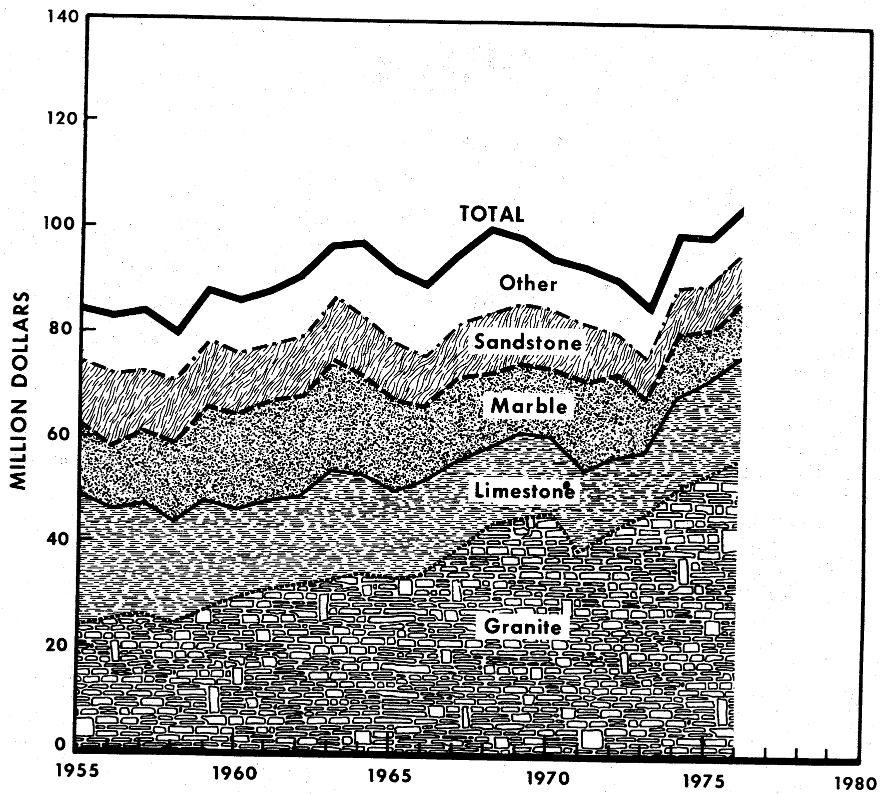

Figure 1.—Value of dimension stone sold or used by producers in the United States, by kind.

The Bureau of Mines generally accepts the classification reported by producers.

Deposits of unconsolidated materials, including beach sands, are generally classified as sand and gravel, regardless of chemical content. However, many deposits of stone are relatively soft and may be mined without blasting. Natural sand deposits are classified as sand and gravel, but manufactured sand (stone sand) is classified as stone.

The Bureau of Mines canvass of dimension stone does not include processors of purchased rough stone. All producers are covered; if the producer sells rough stone to a processor, it is tabulated as rough stone; if the producer processes finished stone, only the finished stone is tabulated, and the rough stone is deducted.

Capacity figures and stocks are not available. Inventories on hand at quarries and plants are estimated at about 1 month's supply, or 100 million tons.

DOMESTIC PRODUCTION

Dimension Stone.—Dimension stone was produced at 450 quarries in 44 States. Leading States were Indiana, Georgia, Vermont, Ohio, and Massachusetts, which accounted for 56% of the total output of dimension stone. Of the total production, 41% was granite, 30% was limestone, 19% was sandstone, 4% was slate, 4% was marble, and 2% was miscellaneous stone. Leading companies were Coggins Granite Industries, Inc., and Rock of Ages Corp. There were 303 companies, and average output per company was 4,600 tons valued at $345,000. Total output of dimension stone was about the same as in 1975, 1.40 million tons valued at $104.4 million.

Crushed Stone.—Crushed stone was produced at 5,214 quarries, in every State except Delaware and North Dakota. Leading States were Pennsylvania, Illinois, Texas, Missouri, and Ohio, which accounted for 30% of the total output of crushed stone. Of the total production, 74% was limestone, 11% was granite, 8% was traprock, 3% was sandstone, 2% was miscellaneous stone, and 2% was shell. There were 1,936 companies, and average output per company was 465,000 tons valued at $1.09 million. Total output of crushed stone was about the same as in 1975, 900 million tons valued at $2.12 billion. Leading companies were Vulcan Materials Co. and Martin Marietta Corp.

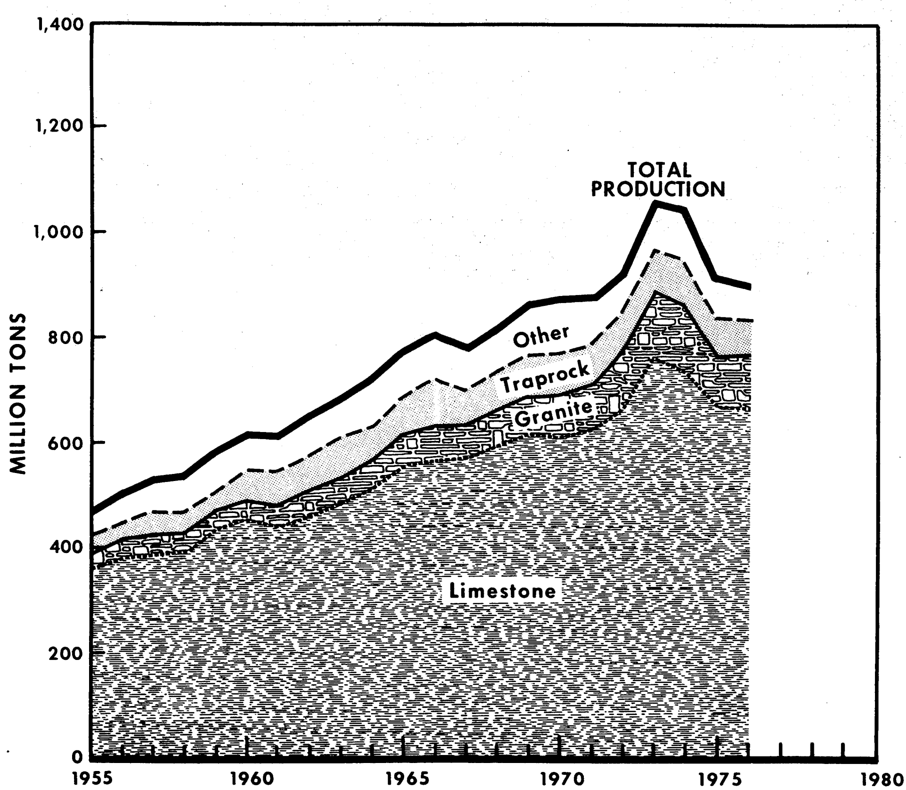

Figure 2.—Crushed stone sold or used by producers in the United States, by kind.

Table 2.—Dimension stone sold or used by producers in the United States, by State

State	1975			1976		
	Short tons	Cubic feet	Value (thousands)	Short tons	Cubic feet	Value (thousands)
Alabama	27,395	351,630	$2,753	17,267	221,420	$2,234
Arizona	4,734	64,647	148	5,423	68,165	95
Arkansas	4,784	59,800	159	W	W	W
California	10,759	130,120	490	12,626	150,630	804
Colorado	5,338	68,153	167	5,904	75,178	198
Connecticut	9,175	107,770	224	9,143	108,800	215
Georgia	249,700	2,546,100	12,345	224,680	2,372,400	13,411
Hawaii	10,154	107,300	102	W	W	W
Idaho	2,393	29,731	190	W	W	W
Illinois	3,479	40,929	79	4,108	48,329	103
Indiana	254,040	3,444,500	11,004	263,240	3,594,100	12,787
Iowa	13,075	153,840	409	W	W	W
Kansas	16,910	235,240	676	W	W	W
Maine	W	W	W	264	3,100	13
Maryland	23,353	296,080	612	25,560	323,670	669
Massachusetts	64,980	781,580	5,096	81,865	984,190	5,352
Michigan	7,357	90,989	138	7,559	93,089	129
Minnesota	42,765	510,040	10,058	36,997	441,060	9,819
Missouri	4,221	51,540	1,006	4,084	49,994	915
Montana	W	W	W	4,374	52,312	152
New Hampshire	65,029	744,610	4,957	62,600	710,280	5,273
New Mexico	9,592	23,708	85	13,699	175,090	105
New York	34,524	371,630	2,178	27,492	291,160	2,211
North Carolina	46,937	532,860	3,502	37,606	432,310	3,830
Ohio	86,161	1,178,600	3,030	87,286	1,181,900	2,936
Oklahoma	20,508	238,330	1,007	9,635	111,010	709
Oregon	1,546	18,187	101	1,376	16,187	97
Pennsylvania	71,231	564,480	4,849	65,112	780,445	4,639
South Carolina	9,364	113,550	495	16,858	204,340	900
South Dakota	41,705	442,480	10,268	36,569	409,200	10,653
Tennessee	15,538	187,060	1,998	19,474	232,570	2,328
Texas	20,782	275,040	2,162	14,609	203,020	1,836
Utah	3,958	50,291	251	6,699	85,815	328
Vermont	120,214	1,064,600	10,935	121,240	1,280,500	11,481
Virginia	14,265	70,964	2,146	10,547	119,590	1,758
Washington	4,425	55,097	326	5,208	64,836	477
Wisconsin	69,248	836,460	4,119	71,764	866,440	4,591
Wyoming	1,904	19,923	50	2,174	25,812	63
Other States[1]	11,384	108,140	472	87,337	1,100,700	3,288
Total[2]	1,402,900	15,986,000	98,586	1,400,400	16,950,000	104,400
Puerto Rico	141,460	1,886,200	907	157,240	2,094,800	1,515

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Florida, Nevada, New Jersey, Rhode Island, West Virginia, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—Crushed stone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1975		1976	
	Quantity	Value	Quantity	Value
Alabama	22,225	58,762	23,815	63,195
Alaska	8,877	26,649	6,727	20,092
Arizona	3,399	10,882	4,142	13,826
Arkansas	17,414	38,637	17,701	39,713
California	33,141	72,251	32,364	74,548
Colorado	5,309	10,773	5,293	12,357
Connecticut	7,323	19,893	6,007	17,383
Florida	39,071	73,372	38,606	74,412
Georgia	29,834	78,812	31,630	85,395
Hawaii	7,559	25,217	6,092	21,193
Idaho	3,313	8,762	3,462	9,122
Illinois	60,637	130,020	61,858	141,440
Indiana	28,693	57,846	28,187	59,418
Iowa	30,323	73,324	30,272	75,921
Kansas	15,890	35,174	16,348	38,228
Kentucky	31,734	67,906	33,378	77,060
Louisiana	10,489	38,260	9,685	28,127
Maine	1,253	3,741	1,443	4,596
Maryland	14,772	42,498	15,683	47,000
Massachusetts	7,105	23,584	7,855	28,150
Michigan	39,938	73,662	41,477	82,202
Minnesota	6,812	13,244	7,530	15,948
Mississippi	1,629	2,730	1,762	2,968
Missouri	46,984	94,529	47,542	97,412
Montana	3,130	6,753	3,464	7,842
Nebraska	4,242	10,322	4,101	11,054
Nevada	1,829	4,524	1,904	5,975
New Hampshire	1,454	2,981	679	1,759
New Jersey	11,821	42,381	11,234	39,012
New Mexico	2,188	4,598	1,921	4,289
New York	31,678	78,751	28,109	72,829
North Carolina	28,261	65,825	30,839	78,632
North Dakota	30	153	--	--
Ohio	46,217	105,550	42,612	104,060
Oklahoma	20,090	35,832	19,625	36,630
Oregon	21,273	40,221	20,348	42,589
Pennsylvania	60,106	144,820	63,542	161,250
Rhode Island	293	1,125	305	1,295
South Carolina	13,826	29,587	13,010	29,790
South Dakota	2,605	5,082	3,204	6,587
Tennessee	[r]38,423	[r]79,189	37,581	83,828
Texas	57,964	104,390	54,841	99,816
Utah	2,482	5,916	2,744	6,681
Vermont	1,104	4,783	1,857	10,962
Virginia	35,369	82,058	36,121	89,965
Washington	7,915	18,428	10,218	23,614
West Virginia	10,583	24,332	9,717	24,133
Wisconsin	20,497	36,037	20,667	36,747
Wyoming	2,881	7,567	2,755	7,567
Total[1]	[r]899,990	[r]2,021,700	900,260	2,116,600
American Samoa	34	146	30	156
Guam	781	1,837	457	1,438
Puerto Rico	13,454	46,608	13,247	45,609
Virgin Islands	254	1,813	279	2,050

[r]Revised.

[1]Data may not add to totals shown because of independent rounding.

Table 4.—Crushed stone sold or used by producers in the United States, by size of operation

(Thousand short tons)

Size range	1975 Number of operations	1975 Quantity	1975 Percent	1976 Number of operations	1976 Quantity	1976 Percent
0 to 25	2,150	16,352	2	2,030	14,583	2
25 to 50	718	25,104	3	705	25,184	3
50 to 75	382	23,274	3	320	19,747	2
75 to 100	301	26,134	3	253	21,894	2
100 to 200	624	88,053	10	668	93,613	10
200 to 300	383	94,393	10	368	89,579	10
300 to 400	234	80,467	9	215	73,701	8
400 to 500	168	74,262	8	177	78,165	9
500 to 600	108	59,857	7	109	59,908	7
600 to 700	83	53,430	6	92	59,348	7
700 to 800	64	47,387	5	65	48,807	5
800 to 900	55	46,624	5	43	36,425	4
900 plus	r155	r264,650	29	169	278,950	31
Total[1]	5,425	r899,990	100	5,214	900,260	100

rRevised.
[1]Data may not add to totals shown because of independent rounding.

Table 5.—Crushed stone sold or used by producers in the United States, by method of transportation

(Thousand short tons)

Method	1975 Quantity	1975 Percent	1976 Quantity	1976 Percent
Truck	r722,050	80	722,220	80
Rail	77,883	9	76,209	9
Water	65,115	7	63,243	7
Other	34,942	4	38,585	4
Total[1]	r899,990	100	900,260	100

rRevised.
[1]Data may not add to totals shown because of independent rounding.

LIMESTONE

Dimension.—Dimension limestone was produced by 66 companies in 18 States. Leading States were Indiana, Wisconsin, Kansas, Minnesota, and Alabama, which accounted for 88% of the total output of dimension limestone. Leading companies were Victor Oolitic Stone Co. and Indiana Limestone Co. Total output of dimension limestone decreased 1% to 414,000 tons valued at $19.8 million. Average production per company was 6,300 tons valued at $300,000.

Crushed.—Crushed limestone was produced by 1,307 companies in 46 States. Leading States were Illinois, Texas, Pennsylvania, Missouri, and Ohio, which accounted for 38% of the total output of crushed limestone. Leading companies were Vulcan Materials Co. and Martin Marietta Corp. Total output of crushed limestone was about the same as in 1975, 663 million tons valued at $1.50 billion. Average production per company was 507,000 tons valued at $1.14 million. The States with no crushed limestone output were Delaware, Louisiana, New Hampshire, and North Dakota.

Table 6.—Dimension limestone sold or used by producers in the United States, by State

State	1975 Short tons	1975 Cubic feet	1975 Value (thousands)	1976 Short tons	1976 Cubic feet	1976 Value (thousands)
California	2,760	34,502	$51	3,410	42,627	$70
Illinois	3,479	40,929	79	4,108	48,329	103
Indiana	W	W	W	258,930	3,530,000	W
Iowa	13,075	153,840	409	W	W	W
Kansas	16,910	235,240	676	W	W	W
Michigan	1,692	19,906	32	W	W	W
Minnesota	--	--	--	14,374	178,040	2,205
Texas	12,512	199,670	251	8,261	126,600	155
Utah	--	--	--	161	2,221	6
Virginia	928	10,917	W	611	7,188	18
Washington	1,694	21,175	52	1,773	22,163	61
Wisconsin	61,944	768,240	1,503	63,815	795,900	1,750
Other States[1]	304,610	3,969,300	15,221	58,334	747,820	15,414
Total[2]	419,610	5,453,700	18,273	413,770	5,500,400	19,782
Puerto Rico	141,463	1,886,200	907	W	W	W

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Alabama, Arizona (1976), Colorado, Florida, Missouri, New Mexico, Ohio, Oklahoma, Rhode Island, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 7.—Crushed limestone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Alabama	20,256	43,900	21,615	49,718
Alaska	1,821	8,730	1,950	8,859
Arizona	2,534	8,008	3,318	10,903
Arkansas	6,339	16,596	7,189	18,126
California	16,576	36,532	14,800	33,298
Colorado	3,920	7,744	3,988	9,482
Connecticut	175	1,310	170	1,290
Florida	38,556	72,034	38,047	73,276
Georgia	4,996	12,152	4,094	10,293
Hawaii	1,362	4,254	1,115	3,832
Idaho	368	821	353	807
Illinois	60,637	130,020	61,858	141,440
Indiana	28,665	57,806	28,163	59,378
Iowa	30,323	73,324	30,272	75,921
Kansas	15,382	33,704	15,734	36,331
Kentucky	W	W	33,340	76,870
Maine	817	2,314	900	2,623
Maryland	10,587	30,546	10,699	31,689
Michigan	38,642	68,669	40,214	77,296
Minnesota	5,003	9,549	5,499	11,608
Mississippi	1,067	1,823	W	W
Missouri	45,809	92,035	45,911	93,733
Montana	1,717	3,642	1,776	3,939
Nebraska	4,242	10,322	4,101	11,054
Nevada	1,667	4,224	1,688	5,567
New Mexico	1,534	3,147	1,449	3,187
New York	29,029	70,258	25,296	63,795
North Carolina	3,954	10,129	4,120	10,801
Ohio	44,940	98,358	41,229	95,063
Oklahoma	19,220	34,342	18,750	34,743
Pennsylvania	46,020	109,470	48,796	124,080
South Dakota	1,876	3,120	2,228	3,788
Tennessee	r38,415	r79,039	W	W
Texas	52,801	91,019	51,653	91,724
Utah	1,871	4,680	2,074	5,550
Vermont	817	4,282	1,051	9,170
Virginia	17,850	39,650	17,788	43,684
Washington	753	1,496	1,009	1,979
West Virginia	10,065	22,887	8,894	21,782
Wisconsin	17,452	28,990	17,705	29,768
Wyoming	1,826	4,378	1,616	4,093
Other States[1]	34,931	83,496	42,453	105,720
Total[2]	r664,820	r1,418,700	662,880	1,496,200
American Samoa	34	146	30	156
Guam	781	1,837	457	1,438
Puerto Rico	10,127	25,984	11,951	42,191

rRevised.
W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Massachusetts, New Jersey, Oregon, Rhode Island, South Carolina, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

GRANITE

Dimension.—Dimension granite was produced by 86 companies in 21 States. Leading States were Georgia (34%), Vermont, Massachusetts (14%), New Hampshire (11%), and South Dakota (6%). Leading companies were Coggins Granite Industries and Rock of Ages Corp. Total production of dimension granite decreased 5% to 574,000 tons valued at $55.9 million. Average output per company was 6,700 tons valued at $650,000.

Crushed.—Crushed granite was produced by 150 companies in 31 States. Leading States were Georgia, North Carolina, Virginia, South Carolina, and Arkansas, which accounted for 79% of the total output of crushed granite. Leading producers were Vulcan Materials Co. and Martin Marietta Corp. Total output of crushed granite increased 4% to 98.3 million tons valued at $240 million. Average production per company was 656,000 tons valued at $1.60 million.

Table 8.—Dimension granite sold or used by producers in the United States, by State

State	1975			1976		
	Short tons	Cubic feet	Value (thousands)	Short tons	Cubic feet	Value (thousands)
California	5,835	71,217	$377	5,240	63,979	$589
Connecticut	4,358	45,997	160	5,424	61,123	154
Georgia	222,330	2,205,300	8,653	195,691	2,016,900	8,241
Maine	W	W	W	264	3,100	13
Massachusetts	64,980	781,580	5,096	81,865	984,190	5,352
Minnesota	22,482	261,870	7,780	W	W	W
Missouri	1,109	12,909	247	1,519	18,169	288
New Hampshire	65,029	744,610	4,957	62,600	710,280	5,273
North Carolina	37,724	468,410	2,875	30,521	380,130	3,186
South Carolina	9,364	113,550	495	16,858	204,340	900
South Dakota	41,705	442,480	10,268	36,569	409,200	10,653
Texas	6,270	75,365	1,679	6,348	76,418	1,681
Vermont	81,177	842,970	7,025	W	W	W
Washington	30	364	1	30	364	2
Wisconsin	6,692	60,420	2,593	7,421	63,793	2,820
Other States[1]	34,533	388,700	1,837	123,880	1,332,900	16,774
Total[2]	603,620	6,515,700	54,042	574,230	6,324,900	55,924

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Colorado, Nevada, New York, Oklahoma, Pennsylvania, Virginia, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 9.—Crushed granite sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1975		1976	
	Quantity	Value	Quantity	Value
Alaska	1,174	5,300	1,074	2,708
Arizona	251	739	149	520
Arkansas	6,343	12,117	6,786	13,186
California	4,300	10,378	5,146	13,214
Colorado	928	1,929	1,134	2,489
Georgia	24,072	56,077	26,838	66,930
Idaho	39	100	1	3
Maine	35	93	W	W
Massachusetts	1,012	2,422	1,266	3,989
Minnesota	1,388	2,769	1,605	3,365
Montana	10	12	13	21
Nevada	149	278	194	351
New Mexico	196	474	W	W
North Carolina	22,303	50,973	22,980	57,764
Oklahoma	35	93	--	--
Oregon	W	W	90	185
Pennsylvania	W	W	494	1,357
South Carolina	9,948	22,529	8,600	21,243
Texas	1	1	8	93
Vermont	16	31	2	5
Virginia	12,590	28,437	12,487	29,987

See footnotes at end of table.

Table 9.—Crushed granite sold or used by producers in the United States, by State —Continued

(Thousand short tons and thousand dollars)

State	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Washington	360	780	1,199	2,171
Wisconsin	776	1,028	886	1,193
Other States[1]	8,332	20,410	7,394	18,978
Total[2]	94,258	216,990	98,328	239,670
Puerto Rico	29	66	(3)	(3)

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Connecticut, Maryland, Michigan (1975), Missouri, New Hampshire, New Jersey, New York, Rhode Island, Utah, Wyoming, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.
[3]Withheld to avoid disclosing individual company confidential data.

TRAPROCK

Dimension.—Dimension traprock was produced by three companies in Hawaii, Washington, and California. Leading companies were J. W. Glover Ltd. and Heatherstone Inc. Output decreased 5% to 1,160 tons valued at $14,300. Average production per company was only 390 tons valued at $4,800.

Crushed.—Crushed traprock was produced by 298 companies in 25 States. The five leading States—Oregon, New Jersey, Washington, Massachusetts, and Connecticut—accounted for 59% of the total output of crushed traprock. Leading producers were the U.S. Forest Service and Ashland Oil Inc. Total output decreased 4% to 75.2 million tons valued at $193 million. Average production per company was 252,000 tons valued at $647,000.

Table 10.—Crushed traprock sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Alaska	3,119	5,763	2,402	4,802
Arizona	41	62	W	W
California	4,390	8,617	3,967	9,165
Connecticut	6,988	17,774	5,651	15,130
Hawaii	5,967	20,265	4,809	16,781
Idaho	2,394	4,969	2,137	4,293
Maryland	W	W	2,546	7,665
Massachusetts	5,362	15,261	5,793	15,892
Michigan	9	17	W	W
Montana	1,083	2,353	1,482	3,302
New Jersey	8,455	29,685	8,259	27,244
New Mexico	381	761	190	444
New York	1,527	5,055	1,662	5,623
North Carolina	1,612	3,948	1,734	4,857
Oregon	19,947	37,289	18,735	38,603
Pennsylvania	4,011	8,776	3,412	8,074
South Dakota	--	--	29	28
Vermont	W	W	51	150
Virginia	3,429	8,252	4,146	10,208
Washington	5,581	12,279	6,279	14,739
Wisconsin	1,134	3,596	1,118	3,792
Other States[1]	3,013	7,880	801	2,084
Total[2]	78,443	192,600	75,202	192,880
Puerto Rico	1,222	2,862	(3)	(3)
Virgin Islands	213	1,490	279	2,050

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Maine, Minnesota, New Hampshire, Texas, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.
[3]Withheld to avoid disclosing individual company confidential data.

SANDSTONE

Dimension.—Dimension sandstone was produced by 91 companies in 27 States. Leading States were Ohio, Pennsylvania, New York, Georgia, and Maryland, which accounted for 60% of the total output of dimension sandstone. Leading producers were Standard Slag Co. and Briar Hill Stone Co. Output was 272,000 tons valued at $10.2 million. Average production per company was 3,000 tons valued at $112,000.

Crushed.—Crushed sandstone was produced by 199 companies in 33 States. Leading States were Pennsylvania, Arkansas, California, and Ohio, which accounted for 51% of the total output of crushed sandstone. Leading producers were Ashland Oil Co. and Ottawa Silica Co. Output decreased 1% to 26.7 million tons valued at $78.5 million. Average production per company was 134,000 tons valued at $395,000.

Table 11.—Dimension sandstone sold or used by producers in the United States, by State

State	1975			1976		
	Short tons	Cubic feet	Value (thousands)	Short tons	Cubic feet	Value (thousands)
Arizona	4,734	64,647	$148	1,579	22,893	$34
Arkansas	4,784	59,800	159	W	W	W
California	371	5,054	11	662	8,737	18
Colorado	4,946	63,440	123	5,277	67,653	132
Connecticut	4,817	61,769	64	3,719	47,680	61
Indiana	W	W	W	4,308	64,620	W
Maryland	W	W	W	12,597	161,630	365
Michigan	5,665	71,083	106	W	W	W
Missouri	580	8,660	27	580	8,660	27
New York	27,970	334,160	1,539	20,649	252,340	1,566
Pennsylvania	30,501	390,870	865	30,630	392,690	894
Tennessee	9,536	122,280	299	9,476	120,820	582
Virginia	1,711	21,392	28	W	W	W
Washington	2,403	30,038	255	3,059	38,238	393
Wisconsin	612	7,800	23	528	6,746	21
Wyoming	150	1,923	2	223	2,859	4
Other States[1]	130,680	1,764,100	4,354	178,900	2,336,400	6,093
Total[2]	229,460	3,007,000	8,001	272,190	3,531,900	10,192
Puerto Rico	--	--	--	(3)	(3)	(3)

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Alabama, Georgia, Idaho, Minnesota, Montana, New Jersey, New Mexico, North Carolina, Ohio, Utah, West Virginia, and States indicated by the symbol W.
[2]Data may not add to totals shown because of independent rounding.
[3]Withheld to avoid disclosing individual company confidential data.

Table 12.—Crushed sandstone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1975		1976	
	Quantity	Value	Quantity	Value
Alabama	57	228	W	W
Alaska	W	W	336	596
Arizona	456	1,429	509	1,603
Arkansas	5,325	9,375	3,603	7,481
California	3,451	7,856	3,413	7,429
Colorado	375	971	W	W
Florida	110	220	--	--
Idaho	482	2,736	819	3,737
Kentucky	W	W	38	190
Maine	W	W	399	1,420
Maryland	313	1,387	214	1,121
Montana	262	665	191	575
New Mexico	W	W	234	437
New York	1,112	3,360	1,126	3,324
North Carolina	W	W	107	547
Ohio	1,277	7,192	1,384	8,995
Oregon	741	1,836	W	W
Pennsylvania	4,672	13,766	5,323	14,535
South Dakota	729	1,962	948	2,771
Tennessee	W	W	3	8
Texas	836	2,359	689	1,941
Vermont	29	50	10	28
Virginia	828	2,182	862	2,298

See footnotes at end of table.

Table 12.—Crushed sandstone sold or used by producers in the United States, by State —Continued

(Thousand short tons and thousand dollars)

State	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Washington	794	2,720	875	2,544
West Virginia	517	1,445	823	2,351
Wyoming	40	89	--	--
Other States[1]	4,714	15,409	4,818	14,574
Total[2]	27,120	77,237	26,723	78,506
Virgin Islands	41	323	--	--

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Connecticut, Georgia, Kansas, Michigan, Minnesota, Missouri, Oklahoma, Utah, Wisconsin, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

MARBLE

Dimension.—Dimension marble was produced by 15 companies in 12 States. Leading States were Vermont, Georgia, Tennessee, Montana, and Alabama, which accounted for 87% of the total output of dimension marble. Leading producers were Georgia Marble Co. and Vermont Marble Co. Output expanded 12% to 56,000 tons valued at $10.3 million. Average output per company was 3,700 tons valued at $688,000.

Crushed.—Crushed marble was produced by 20 companies in 13 States. Leading States were Alabama, Georgia, North Caro-

Table 13.—Dimension marble sold or used by producers in the United States, by State

State	1975 Short tons	1975 Cubic feet	1975 Value (thousands)	1976 Short tons	1976 Cubic feet	1976 Value (thousands)
Idaho	W	W	W	893	10,500	$90
Tennessee	6,002	64,778	$1,699	9,998	111,750	1,746
Texas	2,000	20,000	232	--	--	--
Washington	57	685	2	W	W	W
Wyoming	1,754	18,000	47	1,951	22,953	59
Other States[1]	40,176	456,650	7,547	43,135	492,370	8,423
Total[2]	49,989	560,110	9,526	55,977	637,560	10,318

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Alabama, Arizona (1976), Georgia, Missouri, Montana, New Mexico, North Carolina, Utah (1975), Vermont, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 14.—Crushed marble sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Alabama	610	9,982	649	9,964
Arizona	W	W	43	564
Texas	W	W	68	684
Vermont	4	6	2	6
Wyoming	54	1,340	63	1,574
Other States[1]	794	11,297	632	7,794
Total[2]	1,461	22,626	1,456	20,586
Puerto Rico	107	523	97	518

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes California, Georgia, Missouri, Nevada (1976), North Carolina, Tennessee, Virginia, Washington, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

lina, Texas, and Wyoming, which accounted for 91% of the total production of crushed marble. Leading producers were Georgia Marble Co. and Thompson-Weinman & Co. Output was about the same as in 1975, 1.46 million tons valued at $20.6 million. Average production per company was 72,800 tons valued at $1.03 million.

SLATE

Dimension.—Dimension slate was produced by 29 companies in 6 States. Leading States were Pennsylvania and Vermont, which accounted for 76% of the total output of dimension slate. Other States were Virginia, New York, North Carolina, and California. Leading companies were A. Dalley & Sons Inc. and Stoddard Slate Co., Inc. Output decreased 6% to 58,000 tons valued at $7.26 million. Average production per company was 2,000 tons valued at $250,000.

Crushed.—Crushed slate was produced by eight companies in Virginia, Georgia, Arkansas, and New York. Leading producers were Hercules Inc. and Georgia Lightweight Aggregate Co. Output expanded 16% to 879,000 tons valued at $5.81 million. Average output per company was 110,000 tons valued at $726,000.

SHELL

Crushed shell was produced by 13 companies in Louisiana (68%), Texas, Alabama, Florida (4%), South Carolina, California, and Virginia. Leading companies were Radcliff Materials, Inc., and Parker Bros. & Co., Inc. Output declined 11% to 13.8 million tons valued at $37.4 million. Average production per company was 1.06 million tons valued at $2.88 million.

CALCAREOUS MARL

Crushed marl was produced by 31 companies in 8 States. Leading States were South Carolina, Texas, and Mississippi, which accounted for 92% of the total output of crushed marl. Leading producers were Santee Portland Cement Co. and Giant Portland Cement Co. Output decreased 4% to 3.37 million tons valued at $4.45 million. Average production per company was 109,000 tons valued at $143,000.

Table 15.—Crushed calcareous marl sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1975		1976	
	Quantity	Value	Quantity	Value
Indiana	28	41	24	40
Michigan	85	153	66	156
Mississippi	561	907	W	W
North Carolina	228	461	173	321
South Carolina	2,180	2,778	2,384	2,978
Virginia	W	W	5	9
Other States[1]	421	532	719	943
Total[2]	3,504	4,871	3,371	4,446

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Maine (1976), Texas, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

MISCELLANEOUS STONE

Dimension.—Other kinds of dimension stone were produced by 22 companies in 11 States. Leading States were Maryland, Pennsylvania, California, and Oregon, which accounted for 87% of the total output of other dimension stone. Other States were Arizona, New Mexico, Virginia, Washington, North Carolina, and Hawaii. Leading producers were Stoneyhurst Quarries and Tri State Stone Co. Output declined 32% to 25,000 tons valued at $911,000. Average production per company was only 1,100 tons valued at $41,400.

Crushed.—Other crushed stone was produced by 84 companies in 26 States. Leading States were Pennsylvania, California, North Carolina, Alaska, and Washington, which accounted for 79% of the total output of other crushed stone. Leading producers were the U.S. Forest Service and Eureka Stone Quarry Inc. Output expanded 25% to 17.7 million tons valued at $41.1 million. Average production per company was 210,000 tons valued at $489,000.

Table 16.—Crushed miscellaneous stone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1975		1976	
	Quantity	Value	Quantity	Value
Alaska	1,391	3,899	966	3,127
California	4,409	8,693	5,021	11,107
Colorado	86	128	W	W
Hawaii	230	698	169	580
Idaho	30	136	152	282
Maryland	W	W	470	1,219
Montana	58	81	1	4
North Carolina	W	W	1,624	4,079
North Dakota	30	153	--	--
Oklahoma	W	W	253	276
Oregon	200	331	276	484
Pennsylvania	W	W	5,519	13,200
Rhode Island	12	38	16	56
Utah	574	933	W	W
Vermont	76	114	742	1,602
Virginia	W	W	214	432
Washington	W	W	840	1,752
Other States[1]	7,073	15,796	1,383	2,866
Total[2]	14,169	31,000	17,664	41,099
Puerto Rico	1,969	17,172	--	--

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Includes Arizona, Arkansas, Kansas, Louisiana, Massachusetts, Missouri, Nevada, New Mexico, Texas (1975), Wisconsin, Wyoming, and States indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Stone was consumed in every State. Dimension stone was marketed over wide areas to meet specific requirements. Crushed stone was generally marketed in a limited area, usually in the State where produced. Although large stockpiles may exist, output during the year is considered to equal consumption.

Dimension.—Dimension stone was used for building stone (32%), monuments (24%), rough blocks (19%), and for other uses. Output of rough monumental stone decreased 3% to 271,500 tons valued at $15.2 million. Production of rough blocks decreased 8% to 271,400 tons valued at $9.1 million. Output of cut building stone decreased 5% to 120,800 tons valued at $24 million. Production of rough construction stone increased 19% to 119,000 tons valued at $3.2 million. Output of curbing decreased 4% to 118,500 tons valued at $8.0 million. These five uses accounted for 64% of the total production of dimension stone.

Crushed.—Crushed stone was used for roadstone (55%), concrete (13%), cement (11%), and many other uses. Output of roadbase aggregate declined 12% to 191.2 million tons valued at $401.7 million. Production of other aggregate and roadstone expanded 12% to 131.2 million tons valued at $299.9 million. Output of concrete aggregate decreased 3% to 116.0 million tons valued at $270.6 million. Stone used in cement increased 4% to 99.2 million tons valued at $177.1 million. Production of bituminous aggregate decreased 3% to 86.6 million tons valued at $225.3 million. These five uses accounted for 69% of the total production of crushed stone.

Table 17.—Dimension stone sold or used by producers in the United States, by use

Use	1975			1976		
	Short tons	Cubic feet	Value (thousands)	Short tons	Cubic feet	Value (thousands)
Rough Monumental	279,960	2,815,300	$15,540	271,460	2,829,300	$15,223
Rough blocks	293,580	3,688,400	9,649	271,449	3,477,500	9,108
Cut building stone	127,320	1,627,100	22,916	120,780	1,550,200	23,978
Rough construction	99,971	1,254,700	2,101	119,050	1,493,300	3,197
Curbing	122,980	1,455,000	7,787	118,470	1,396,200	8,048
Rubble	106,820	1,226,400	1,184	113,220	1,426,300	1,339
Sawed building stone	89,405	1,197,200	5,421	91,387	1,214,100	5,306
House stone veneer	81,187	1,041,200	3,775	84,997	1,113,900	3,961
Dressed monumental	49,576	547,170	15,043	65,804	737,950	22,031
Dressed flagging	W	W	W	38,687	441,000	1,730
Rough flagging	36,225	458,580	1,425	38,158	485,570	1,574
Dressed construction	31,231	397,560	4,826	25,563	312,070	2,078
Structural shapes	W	W	W	10,275	117,000	2,588
Roofing slate	W	W	W	9,960	113,000	2,045
Flooring slate	W	W	W	6,205	66,390	1,046
Billiard tables	W	W	W	1,772	20,000	405
Blackboards	W	W	W	193	2,200	101
Other rough stone	5,059	59,674	75	6,159	76,200	--
Other dressed stone	6,283	17,930	709	4,675	53,000	264
Other uses[1]	73,306	199,850	8,135	2,082	24,830	210
Total[2]	1,402,900	15,986,000	98,586	1,400,400	16,950,000	104,400

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes paving blocks, electrical fixtures, other uses, and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 18.—Crushed stone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1975		1976	
	Quantity	Value	Quantity	Value
Roadbase aggregate	[r]214,820	[r]437,800	191,160	401,710
Other aggregate and roadstone	117,150	264,880	131,170	299,880
Concrete aggregate	119,660	261,350	116,000	270,610
Cement	95,506	167,200	99,208	177,080
Bituminous aggregate	89,552	255,800	86,639	225,330
Surface treatment aggregate	52,144	119,840	54,708	131,670
Agricultural limestone (agstone)	33,846	87,635	39,995	107,440
Lime[1]	35,009	76,084	37,756	88,474
Macadam aggregates	27,955	57,977	27,556	61,356
Riprap	26,310	52,568	27,075	61,043
Flux stone	23,819	54,500	23,767	57,621
Railroad ballast	20,840	42,881	23,204	50,354
Fill	5,293	8,080	4,933	8,656
Stone sand	6,822	18,219	4,824	14,192
Roofing granules	4,381	11,236	4,394	11,798
Glass	3,000	16,252	3,199	18,772
Other fillers	2,888	27,459	2,908	30,769
Mineral food	1,962	11,450	2,437	13,881
Rock dust for coal mines	1,149	6,008	1,377	8,026
Other chemicals	1,192	2,008	1,095	1,877
Ferrosilicon	932	2,455	1,007	2,814
Whiting	1,014	17,050	976	19,726
Filter stone	727	1,888	928	2,510
Asphalt filler	751	3,745	832	4,478
Refractory stone	965	6,631	775	5,045
Sulfur dioxide removal	--	--	655	1,496
Terrazzo	584	7,259	614	7,069
Lightweight aggregate	510	4,107	523	4,385
Agricultural marl	584	1,765	469	1,468
Drain fields	86	187	323	448
Waste products	401	439	303	378
Paper	135	611	136	656
Bedding material	161	316	135	391
Building products	260	642	122	282
Abrasives	81	707	99	706
Acid neutralization	55	180	27	173
Other uses[2]	9,446	24,291	8,929	24,049
Total[3]	[r]899,990	[r]2,0221,700	900,260	2,116,600

[r]Revised.
[1]Includes dead-burned dolomite, alkalies, and sugar.
[2]Includes magnesium metal (1976), porcelain, slate flour, stucco, disinfectant, carbon dioxide (1975), and other uses.
[3]Data may not add to totals shown because of independent rounding.

LIMESTONE

Dimension.—Dimension limestone was used for building stone (48%), as rough blocks (33%), for rubble (13%), and for other purposes. Output of rough blocks declined 15% to 137,600 tons valued at $3.7 million. Production of cut building stone increased 8% to 58,700 tons valued at $8.7 million. Output of house stone veneer increased 4% to 57,800 tons valued at $2.3 million. Production of rubble expanded 51% to 55,400 tons valued at $610,000. Output of sawed building stone declined 12% to 47,800 tons valued at $3.1 million. These five uses accounted for 86% of the total production of dimension limestone.

Crushed.—Crushed limestone was used for roadstone (50%), cement (14%), concrete aggregate (14%), and many other purposes. Output of roadbase aggregate declined 10% to 136.2 million tons valued at $272.1 million. Production of stone for cement increased 6% to 93.4 million tons valued at $166.3 million. Output of concrete aggregate decreased 4% to 90.6 million tons valued at $203.1 million. Production of other aggregate and roadstone expanded 10% to 80.5 million tons valued at $175.9 million. Output of bituminous aggregate declined 10% to 52.0 million tons valued at $127.2 million. These five uses accounted for 67% of the total production of crushed limestone.

A study was made of the output of agricultural and industrial limestone during the period 1940-76. Output of stone for cement more than tripled from 34.0 million tons in 1940 to a record 106.9 million tons in 1973. Output of stone for lime (including dead-burned dolomite, alkalies, and sugar) more than doubled, from 16.0 million tons in 1940 to a record 40.1 million tons in 1973. Output of aglime expanded more than four times, from 8.7 million tons in 1940 to a record 39.8 million tons. Output of flux stone expanded from 22.9 million tons in 1940 to a record 40.9 million tons in 1953; since 1953 output has declined 45% to 22.5 million tons. Output of stone for fillers (whiting, asphalt filler, and other fillers) expanded from 856,000 tons in 1940 to a record 4.8 million tons in 1962; since 1962, output has declined 32% to 3.3 million tons. Output of stone for glass expanded seven times, from 301,000 tons in 1940 to 2.1 million tons. Output of stone for mineral food expanded 16 times, from 132,000 tons in 1940 to a record 2.1 million tons in 1974. Output of stone used as rock dust in coal mines expanded 14 times, from 99,000 tons in 1940 to 1.4 million tons. Output of stone for other industrial and agricultural uses expanded eight times, from 414,000 tons in 1940 to 3.4 million tons. Total output for these uses more than doubled, from 83.5 million tons in 1940 to 204.8 million tons.

Table 19.—Dimension limestone sold or used by producers in the United States, by use

Use	1975			1976		
	Short tons	Cubic feet	Value (thousands)	Short tons	Cubic feet	Value (thousands)
Rough blocks	162,400	2,173,700	$4,045	137,580	1,864,600	$3,713
Cut stone	54,339	723,490	6,941	58,669	781,980	8,693
House stone veneer	55,650	732,880	2,267	57,756	763,540	2,331
Rubble	36,716	373,460	427	55,420	713,550	614
Sawed stone	54,467	742,200	3,416	47,830	654,300	3,109
Rough construction	25,203	320,630	530	23,599	305,560	601
Rough flagging	16,216	207,460	301	18,384	237,610	336
Dressed construction	10,786	131,720	248	11,768	144,320	297
Dressed flagging	2,001	25,378	78	2,386	30,505	82
Curbing	W	W	W	257	3,115	4
Other rough stone	W	W	W	114	1,341	2
Other dressed stone	W	W	W	3	38	1
Other uses[1]	1,832	22,777	20	--	--	--
Total[2]	419,610	5,453,700	18,273	413,770	5,500,400	19,782

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 20.—Crushed limestone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1975		1976	
	Quantity	Value	Quantity	Value
Roadbase aggregate	r150,260	r287,710	136,520	272,100
Cement	88,326	151,010	93,407	166,260
Concrete aggregate	94,305	198,640	90,575	203,140
Other aggregate and roadstone	73,097	151,400	80,491	175,910
Bituminous aggregate	57,816	140,290	51,972	127,230
Agricultural limestone (aglime)	33,570	86,888	39,825	106,670
Surface treatment aggregate	38,398	88,586	38,476	94,222
Lime[1]	34,002	72,901	36,918	86,583
Macadam aggregate	23,777	48,685	23,837	51,457
Flux stone	22,756	49,707	22,508	51,936
Riprap	13,718	28,333	15,174	35,173
Railroad ballast	9,482	18,653	9,671	19,729
Stone sand	4,363	11,087	3,494	9,621
Glass	2,021	10,207	2,119	11,961
Mineral food	1,616	10,015	1,979	12,321
Other filler	1,892	14,200	1,845	14,536
Fill	2,094	2,997	1,448	2,433
Rock dust for coal mines	1,149	6,008	1,377	8,026
Other chemicals	1,192	2,008	1,095	1,877
Ferrosilicon	W	W	914	2,254
Whiting	744	11,537	897	18,333
Sulfur dioxide removal	--	--	654	1,494
Asphalt filler	658	3,277	576	2,976
Filter stone	294	721	422	1,043
Roofing granules	278	1,046	393	1,315
Agricultural marl	377	1,288	321	1,056
Waste products	401	439	303	378
Drain fields	56	109	300	392
Terrazzo	175	1,364	204	1,847
Paper	135	611	136	656
Bedding material	79	143	44	87
Refractory stone	76	277	33	89
Acid neutralization	55	180	27	173
Abrasives	W	W	18	168
Building products	110	209	W	W
Other uses[2]	7,539	17,939	5,178	12,792
Total[3]	r664,820	r1,418,700	662,880	1,496,200

rRevised. W Withheld to avoid disclosing individual company confidential data; included with "Other uses."

[1]Includes dead-burned dolomite, alkalies, and sugar.

[2]Includes magnesium metal (1976), stucco, disinfectant, carbon dioxide (1975), other uses, and uses indicated by symbol W.

[3]Data may not add to totals shown because of independent rounding.

Table 21.—Crushed limestone sold or used by producers in the United States in 1976, by State and use

(Thousand short tons and thousand dollars)

State	Aggregates		Cement		Aglime		Lime[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	3,619	7,558	1,478	5,117	2,021	6,568
Alaska	1,850	8,759	--	--	--	--	--	--
Arizona	257	591	W	W	W	W	898	3,472
Arkansas	3,278	11,067	1,812	2,318	544	1,379	W	W
California	1,726	3,161	10,327	17,759	35	194	1,458	4,005
Colorado	W	W	W	W	W	W	174	673
Connecticut	--	--	--	--	W	W	W	W
Florida	33,148	62,060	1,825	2,509	1,104	3,444	W	W
Georgia	W	W	1,195	2,318	118	338	--	--
Hawaii	W	W	736	1,795	29	151	W	W
Idaho	--	--	W	W	--	--	--	--
Illinois	48,484	108,270	2,887	5,005	6,613	15,299	858	1,749
Indiana	W	W	3,161	4,012	3,324	7,231	--	--
Iowa	20,296	51,049	3,721	7,436	4,155	10,947	W	W
Kansas	11,164	27,470	3,268	6,212	864	1,673	--	--
Kentucky	23,325	53,060	957	1,581	2,453	5,708	851	1,710
Maine	142	517	W	W	W	W	--	--
Maryland	W	W	2,092	2,533	W	W	32	74
Massachusetts	W	W	--	--	W	W	W	W
Michigan	9,122	17,404	8,273	14,898	510	1,142	11,120	20,706
Minnesota	W	W	--	--	598	1,534	--	--
Mississippi	W	W	W	W	W	W	--	--
Missouri	W	W	6,158	9,849	5,038	11,123	3,430	5,511
Montana	69	169	W	W	--	--	309	941
Nebraska	W	W	W	W	259	636	--	--
Nevada	272	345	W	W	--	--	W	W
New Mexico	W	W	W	W	4	13	70	W
New York	W	W	4,643	6,973	258	1,359	W	W
North Carolina	3,203	8,481	W	W	W	W	--	--
Ohio	24,473	53,933	3,414	8,334	2,153	6,137	4,273	7,708
Oklahoma	13,850	25,850	2,323	3,137	448	827	W	W
Pennsylvania	29,459	66,580	8,345	16,551	1,786	8,484	3,635	10,703
South Carolina	1,204	2,999	--	W	W	W	--	--
South Dakota	W	W	680	900	W	W	W	W
Tennessee	30,685	66,653	1,815	4,153	2,936	6,864	W	W
Texas	W	W	7,558	10,399	348	558	2,004	3,960
Utah	W	W	922	2,455	W	W	W	W
Vermont	W	W	--	--	W	W	--	--
Virginia	11,473	26,523	1,340	2,603	1,882	6,062	1,663	3,746
Washington	W	W	W	W	14	159	--	--
West Virginia	W	W	W	W	111	406	W	W
Wisconsin	W	W	--	--	1,275	3,001	--	--
Wyoming	462	1,028	W	W	--	--	W	W

See footnotes at end of table.

Table 21.—Crushed limestone sold or used by producers in the United States in 1976, by State and use —Continued

(Thousand short tons and thousand dollars)

State	Aggregates		Cement		Aglime		Lime[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Other States[4]	157,160	337,770	12,336	24,972	1,488	6,834	4,122	15,057
Total[3]	425,100	933,670	93,407	166,260	39,825	106,670	36,918	86,583
American Samoa	30	156	--	--	--	--	--	--
Guam	W	W	--	--	W	W	--	--
Puerto Rico	8,824	37,308	3,066	4,737	--	--	29	48

State	Flux stone		Riprap		Other uses[2]		Total[3]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	1,385	2,718	437	1,088	12,675	26,669	21,615	49,718
Alaska	--	--	100	100	--	--	1,950	8,859
Arizona	577	1,917	--	--	1,586	4,923	3,318	10,903
Arkansas	W	W	265	516	1,290	2,846	7,189	18,126
California	W	W	4	9	1,250	8,170	14,800	33,298
Colorado	W	W	W	W	3,814	8,807	3,988	9,480
Connecticut	--	--	--	--	170	1,290	170	1,290
Florida	--	--	212	832	1,758	4,431	38,047	73,276
Georgia	--	--	W	W	2,781	7,587	4,094	10,293
Hawaii	--	--	--	--	350	1,886	1,115	3,832
Idaho	--	--	W	W	353	807	353	807
Illinois	349	751	779	1,776	1,868	8,558	61,838	141,410
Indiana	19	43	294	842	21,365	47,250	28,163	59,378
Iowa	W	W	176	554	1,924	5,935	30,272	75,921
Kansas	--	--	140	300	478	676	15,734	36,331
Kentucky	W	W	4,541	11,006	1,213	3,805	33,340	76,870
Maine	--	--	W	W	758	2,106	900	2,623
Maryland	W	W	--	--	8,575	29,082	10,699	31,689
Massachusetts	W	W	W	W	675	8,025	675	8,025
Michigan	10,375	21,566	375	730	439	850	40,214	77,296
Minnesota	--	--	79	164	4,822	9,910	5,499	11,608
Mississippi	--	--	W	W	1,462	2,588	1,462	2,588
Missouri	W	W	2,675	4,101	28,610	63,149	45,911	93,733
Montana	296	691	5	10	1,097	2,128	1,776	3,939
Nebraska	--	--	214	803	3,628	9,615	4,101	11,054
Nevada	W	W	7	11	1,409	5,211	1,688	5,567
New Mexico	W	W	--	--	1,375	3,174	1,449	3,187
New York	W	W	633	2,249	19,762	53,214	25,296	63,795
North Carolina	--	--	W	W	917	2,320	4,120	10,801
Ohio	3,567	7,968	1,039	2,547	2,310	8,436	41,229	95,063
Oklahoma	--	--	841	1,646	1,288	3,283	18,750	34,743
Pennsylvania	2,778	9,278	567	1,401	2,226	9,085	48,796	124,080
South Carolina	--	--	W	W	439	1,504	1,643	4,503
South Dakota	--	--	57	145	1,491	2,743	2,228	3,788
Tennessee	--	--	594	1,262	1,544	4,745	37,574	83,677
Texas	298	730	526	1,202	40,919	74,875	51,653	91,724
Utah	W	W	38	47	1,114	3,048	2,074	5,550
Vermont	--	--	22	57	1,029	9,113	1,051	9,170
Virginia	345	804	35	91	1,050	3,855	17,788	43,684
Washington	--	--	W	W	995	1,820	1,009	1,979
West Virginia	W	W	23	81	8,760	20,808	8,894	21,782
Wisconsin	--	--	149	457	16,281	26,310	17,705	29,768
Wyoming	--	--	W	W	1,154	3,065	1,616	4,093

Other States[4]	2,519	5,470	347	1,146	[5]27,948	[5]115,910	[6]1,100	[6]6,927
Total[3]	22,508	51,936	15,174	35,173	[5]27,948	[5]115,910	662,880	1,496,200
American Samoa	--	--	--	--	--	--	30	156
Guam	--	--	--	--	457	1,438	457	1,438
Puerto Rico	--	--	W	W	32	98	11,951	42,191

W Withheld to avoid disclosing individual company confidential data; included with "Other States" and with "Other uses."
[1]Includes dead-burned dolomite, alkalies, and sugar.
[2]Includes concealed uses and other uses.
[3]Data may not add to totals shown because of independent rounding.
[4]Includes New Jersey, Oregon, Rhode Island, and States indicated by symbol W.
[5]Includes other uses only: Railroad ballast, glass, mineral food, other filler, fill, rock dust for coal mines, other chemicals, ferrosilicon, whiting, sulfur dioxide removal from stack gases, asphalt filler, filter stone, roofing granules, soil conditioning, waste material, drain fields, terrazzo, magnesium metal, paper, building products, bedding material, refractory stone, acid neutilization, abrasives, stucco, disinfectant, and other uses.
[6]Concealed States only.

GRANITE

Dimension.—Dimension granite was used for monuments (56%), curbing (21%), building stone (13%), and other purposes. Output of rough monumental stone decreased 5% to 266,500 tons valued at $14.9 million. Production of curbing decreased 4% to 118,000 tons valued at $8.0 million. Output of dressed monumental stone expanded 18% to 54,700 tons valued at $18.1 million. Production of rough blocks declined 48% to 31,500 tons valued at $1.1 million. Output of cut building stone declined 24% to 29,300 tons valued at $10.3 million. These five uses accounted for 87% of the total production of dimension granite.

Crushed.—Crushed granite was used for roadstone (63%), concrete (17%), and other purposes. Output of roadbase aggregate declined 24% to 22.8 million tons valued at $53.0 million. Production of other aggregates and roadstone expanded 43% to 17.8 million tons valued at $43.8 million. Output of concrete aggregates increased 8% to 17.2 million tons valued at $43.3 million. Production of bituminous aggregate increased 7% to 16.2 million tons valued at $42.8 million. Output of railroad ballast expanded 22% to 9.1 million tons valued at $20.6 million. These five uses accounted for 84% of the total production of crushed granite.

TRAPROCK

Dimension.—Dimension traprock was used for rubble, rough blocks, and rough construction stone

Crushed.—Crushed traprock was used for roadstone (77%), and other purposes. Output of other aggregates and roadstone increased 7% to 18.5 million tons valued at $48.9 million. Production of roadbase aggregate declined 15% to 16.3 million tons valued at $38.7 million. Output of bituminous aggregate decreased 6% to 11.8 million tons valued at $33.9 million. Production of surface treatment aggregate expanded 30% to 9.6 million tons valued at $21.8 million. Output of concrete aggregate declined 25% to 5.1 million tons valued at $15.4 million. These five uses accounted for 82% of the total production of crushed traprock.

SANDSTONE

Dimension.—Dimension sandstone was used for building stone (48%), other rough stone (18%), rough blocks (12%), rubble (10%), and other purposes. Output of rough construction stone decreased 3% to 50,100 tons valued at $1.1 million. Output of other rough stone was 48,300 tons valued at $1.6 million. Production of sawed building stone expanded 72% to 34,700 tons valued at $1.7 million. Production of rough blocks declined 26% to 32,500 tons valued at $550,000. Output of rubble declined 20% to 28,300 tons valued at $370,000. These five uses accounted for 71% of the total production of dimension sandstone.

Crushed.—Crushed sandstone was used for roadstone (61%), concrete aggreate (8%), and other purposes. Output of roadbase aggregate increased 6% to 6.8 million tons valued at $14.9 million. Production of other aggregate and roadstone declined 13% to 4.9 million tons valued at $10.9 million. Output of bituminous aggregate expanded 31% to 3.1 million tons valued at $8.1 million. Production of concrete aggregate increased 2% to 2.2 million tons valued at $6.6 million. Output of riprap declined 13% to 1.6 million tons valued at $3.8 million. These five uses accounted for 69% of the total production of crushed sandstone.

MARBLE

Dimension.—Dimension marble was used for rough blocks (41%), monuments, building stone, and other purposes. Output of rough blocks declined 10% to 23,200 tons valued at $2.2 million. Production of dressed monumental stone was 11,100 tons valued at $3.9 million. Output of cut building stone expanded 40% to 6,800 tons valued at $2.8 million. Production of rough construction stone was 3,958 tons valued at $116,000. These four uses accounted for 80% of the total production of dimension marble.

Crushed.—Crushed marble was used for fillers, terrazzo (12%), roadstone, and other purposes. Output of stone for other fillers expanded 22% to 920,000 tons valued at $14.4 million. Production of terrazzo declined 27% to 170,000 tons valued at $3.6 million. Output of other aggregates and roadstone was 152,000 tons valued at $322,000. These three uses accounted for 85% of the total production of crushed marble.

Table 22.—Dimension granite sold or used by producers in the United States, by use

Use	1975 Short tons	1975 Cubic feet	1975 Value (thousands)	1976 Short tons	1976 Cubic feet	1976 Value (thousands)
Rough monumental	279,460	2,808,600	$15,530	266,480	2,769,900	$14,925
Curbing	122,440	1,448,200	7,761	117,930	1,389,200	8,015
Dressed Monumental	46,379	510,240	14,103	54,726	608,160	18,143
Rough blocks	60,794	630,700	2,206	31,492	334,270	1,082
Cut stone	38,601	466,200	12,244	29,318	354,530	10,300
Rough construction	6,430	77,349	193	27,510	329,980	1,016
Rubble	19,481	213,630	158	20,924	232,520	171
Dressed construction	8,066	99,636	1,085	10,794	131,720	1,662
Sawed stone	12,889	156,330	350	7,776	92,770	217
Other rough stone	W	W	W	2,791	28,057	94
House stone veneer	1,664	19,791	102	1,875	22,255	107
Rough flagging	387	4,707	12	207	3,148	9
Other dressed stone	W	W	W	69	692	7
Other uses[1]	7,027	80,328	298	2,345	27,734	176
Total[2]	603,620	6,515,700	54,042	574,230	6,324,900	55,924

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes paving blocks and dressed flagging and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 23.—Crushed granite sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Roadbase aggregate	30,139	67,759	22,828	52,969
Other aggregates and roadstone	12,409	28,177	17,775	43,769
Concrete aggregate	15,900	36,868	17,198	43,317
Bituminous aggregates	15,113	37,913	16,225	42,759
Railroad ballast	7,433	15,767	9,096	20,574
Riprap	2,457	7,031	4,283	9,989
Surface treatment aggregate	4,173	9,714	3,430	7,842
Macadam aggregate	2,452	4,740	1,685	3,937
Roofing granules	1,597	2,849	1,683	3,038
Stone sand	1,365	8,076	723	1,764
Terrazzo	115	669	181	826
Filter stone	147	383	180	584
Mineral food	81	433	168	757
Fill	131	194	154	210
Bedding material	4	13	60	215
Other uses[1]	742	1,406	2,660	7,120
Total[2]	94,258	216,990	98,328	239,670

[1]Includes asphalt filler and other uses.
[2]Data may not add to totals shown because of independent rounding.

Table 24.—Crushed traprock sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Other aggregates and roadstone	17,258	45,818	18,462	48,879
Roadbase aggregate	19,152	43,634	16,340	38,729
Bituminous aggregate	12,511	35,803	11,762	33,897
Surface treatment aggregate	7,399	16,443	9,623	21,798
Concrete aggregate	6,880	18,817	5,143	15,360
Riprap	7,066	11,049	4,410	8,949
Railroad ballast	2,558	5,991	2,998	6,975
Fill	1,248	1,684	2,137	4,270
Roofing granules	1,650	4,677	1,763	5,185
Macadam aggregate	1,180	3,398	1,573	5,050
Filter stone	222	643	233	623
Stone sand	536	2,084	158	863
Bedding material	57	117	26	81
Drain fields	27	69	20	46
Building products	W	W	1	1

See footnotes at end of table.

Table 24.—Crushed traprock sold or used by producers in the United States, by use —Continued

(Thousand short tons and thousand dollars)

Use	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Other uses[1]	699	2,376	553	2,170
Total[2]	78,443	192,600	75,202	192,880

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes asphalt filler, other fillers (1975), other uses, and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 25.—Dimension sandstone sold or used by producers in the United States, by use

Use	1975			1976		
	Short tons	Cubic feet	Value (thousands)	Short tons	Cubic feet	Value (thousands)
Rough construction	51,506	654,620	$974	50,124	642,120	$1,103
Other rough stone	W	W	W	48,263	603,290	1,563
Sawed stone	20,186	278,530	1,208	34,688	455,700	1,725
Rough blocks	43,632	589,260	868	32,473	446,610	553
Rubble	35,320	466,150	395	28,324	377,410	367
Cut stone	25,835	337,050	1,750	24,827	320,280	2,039
House stone veneer	20,346	272,790	705	21,781	288,240	882
Rough flagging	19,524	245,220	1,108	19,512	244,150	1,227
Dressed flagging	8,700	107,320	414	10,040	126,550	476
Other dressed stone	W	W	W	582	7,196	194
Other uses[1]	4,412	56,086	580	1,572	20,385	75
Total[2]	229,460	3,007,000	8,001	272,190	3,531,900	10,192

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes dressed construction, rough monumental, curbing, dressed monumental (1975), and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 26.—Crushed sandstone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Roadbase aggregate	6,401	13,914	6,798	14,940
Other aggregate and roadstone	5,588	12,515	4,886	10,862
Bituminous aggregate	2,345	6,482	3,067	8,141
Concrete aggregate	2,185	6,068	2,223	6,645
Riprap	1,812	3,954	1,575	3,819
Flux stone	1,063	4,793	1,259	5,685
Surface treatment aggregate	1,392	3,482	1,237	2,895
Railroad ballast	962	2,008	1,116	2,587
Glass	979	6,045	1,080	6,810
Cement	718	1,936	757	2,186
Refractory stone	889	6,354	741	4,956
Stone sand	554	1,914	442	1,792
Roofing granules	684	1,623	W	W
Macadam aggregate	329	811	241	555
Fill	477	919	190	285
Other filler	W	W	142	1,838
Ferrosilicon	W	W	93	559
Abrasives	61	528	81	539
Filter stone	37	78	66	198
Terrazzo	14	117	43	573
Building products	149	431	W	W
Mineral food	W	W	5	17
Bedding material	W	W	5	7
Other uses[1]	481	3,264	676	2,615
Total[2]	27,120	77,237	26,723	78,506

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes porcelain, drain fields, other uses, and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 27.—Dimension marble sold or used by producers in the United States, by use

Use	1975			1976		
	Short tons	Cubic feet	Value (thousands)	Short tons	Cubic feet	Value (thousands)
Rough blocks	25,665	281,990	$2,491	23,176	254,120	$2,207
Dressed monumental	W	W	W	11,078	129,790	3,888
Cut stone	4,851	57,077	1,636	6,805	79,712	2,847
Rough construction	W	W	W	3,958	46,560	116
House stone veneer	2,853	10,244	679	W	W	W
Rubble	W	W	W	2,505	29,468	87
Sawed stone	1,323	14,141	300	1,093	11,343	255
Other uses[1]	15,297	196,660	4,420	7,362	86,576	916
Total[2]	49,989	560,110	9,526	55,977	637,560	10,318

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes rough monumental stone (1976), dressed construction stone, dressed flagging, rough flagging, other dressed stone, and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 28.—Crushed marble sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1975		1976	
	Quantity	Value	Quantity	Value
Other filler	747	11,386	915	14,373
Terrazzo	234	4,759	170	3,598
Other aggregates and roadstone	W	W	152	322
Roofing granules	47	513	W	W
Stone sand	W	W	7	151
Riprap	W	W	6	19
Mineral food	W	W	1	22
Other uses[1]	433	5,968	205	2,100
Total[2]	1,461	22,626	1,456	20,586

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes agstone (1976), whiting, concrete aggregate, macadam aggregate (1976), surface treatment aggregate (1976), roadbase aggregate (1975), other uses (1975), and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

SLATE

Dimension.—Dimension slate was used for flagging (44%), structural shapes (17%), roofing (17%), flooring (11%), and other purposes. Output of flagging increased 1% to 25,500 tons valued at $1.1 million. Production of structural shapes declined 15% to 10,000 tons valued at $2.4 million. Output of roofing declined 10% to 10,000 tons valued at $2.0 million. Production of flooring decreased 1% to 6,200 tons valued at $1.0 million. These four uses accounted for 89% of the total production of dimension slate.

Crushed.—Crushed slate was used for lightweight aggregate (59%), roadstone, roofing granules, and other purposes. Total output expanded 16% to 879,000 tons valued at $5.81 million.

SHELL

Crushed shell was used for roadstone, cement (15%), and other purposes. Output of other aggregate and roadstone declined 21% to 4.9 million tons valued at $10.8 million. Production of roadbase aggregate decreased 4% to 3.4 million tons valued at $9.7 million. Output of shell for cement declined 43% to 2.1 million tons valued at $5.9 million. These three uses accounted for 75% of the total production of crushed shell.

CALCAREOUS MARL

Crushed marl was used for cement (87%), roadstone, agstone, and fill. Output of marl for cement increased 8% to 2.92 million tons valued at $3.53 million. Total production of marl decreased 4% to 3.37 million tons valued at $4.45 million.

MISCELLANEOUS STONE

Dimension.—Other dimension stone was used for construction, rubble (20%), and other purposes. Output of rough construction stone declined 15% to 13,800 tons valued at $360,000. Production of rubble declined 58% to 5,000 tons valued at $95,000. These two uses accounted for 75% of the total production of other dimension stone.

Crushed.—Other crushed stone was used for roadstone (78%), and other purposes. Output of roadbase aggregate decreased 4% to 5.4 million tons valued at $12.8 million. Production of other aggregate and roadstone expanded 79% to 4.4 million tons valued at $9.1 million. Output of bituminous aggregate expanded 44% to 2.4 million tons valued at $7.4 million. These three uses accounted for 69% of the total production of other crushed stone.

Table 29.—Dimension slate sold or used by producers in the United States, by use

Use	1975		1976	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Flagging	25,269	$1,055	25,489	$1,141
Structural shapes	11,835	2,417	10,065	2,408
Roofing	11,003	2,166	9,960	2,045
Flooring	6,274	969	6,205	1,046
Billiard tables	1,987	457	1,772	405
House stone veneer	W	W	198	4
Blackboards	264	136	193	101
Electrical fixtures	340	56	W	W
Other uses[1]	4,961	196	4,166	107
Total[2]	61,933	7,453	58,048	7,257

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes monumental stone (1975), other uses, and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 30.—Crushed shell sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1975		1976	
	Quantity	Value	Quantity	Value
Other aggregate and roadstone	6,182	22,068	4,892	10,842
Roadbase aggregate	3,486	11,690	3,363	9,722
Cement	3,725	10,806	2,125	5,111
Bituminous aggregate	252	1,057	1,248	5,856
Lime	993	3,122	W	W
Concrete aggregate	10	20	W	W
Other uses[1]	806	3,908	2,125	5,862
Total[2]	15,453	52,671	13,753	37,393

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes surface treatment aggregate, mineral food, fill (1976), agstone, railroad ballast, riprap (1975), other uses, and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 31.—Other dimension stone sold or used by producers in the United States, by use

Use	1975 Short tons	1975 Cubic feet	1975 Value (thousands)	1976 Short tons	1976 Cubic feet	1976 Value (thousands)
Rough construction	16,202	194,670	$365	13,829	168,790	$361
Rubble	12,020	147,330	133	5,006	61,040	95
Rough blocks	979	11,364	31	W	W	W
Cut stone	3,694	43,265	345	1,159	13,696	99
House stone veneer	471	5,540	18	717	8,455	31
Rough flagging	79	969	3	27	338	1
Other uses[1]	3,636	62,172	380	4,265	50,863	323
Total[2]	37,081	465,310	1,277	25,003	303,180	911

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes dressed construction stone, dressed flagging, structural shapes, other rough stone, curbing, sawed stone, and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 32.—Other crushed stone sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1975 Quantity	1975 Value	1976 Quantity	1976 Value
Roadbase aggregate	5,571	13,460	5,359	12,818
Other aggregate and roadstone	2,465	4,660	4,405	9,135
Bituminous aggregate	1,646	4,516	2,366	7,444
Riprap	1,211	1,942	1,628	3,095
Surface treatment aggregate	705	1,484	1,487	3,778
Fill	1,277	2,234	833	1,290
Concrete aggregate	386	908	785	1,894
Railroad ballast	389	381	303	435
Macadam aggregate	218	344	217	346
Roofing granules	46	223	W	W
Filter stone	27	63	26	63
Terrazzo	46	349	17	225
Other uses[1]	182	436	238	577
Total[2]	14,169	31,000	17,664	41,099

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1]Includes other fillers, drain fields, cement, alkalies (1975), bedding material (1975), building products (1975), other uses, and uses indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

PRICES

Values are the company-reported average selling prices f.o.b. quarry or plant, and do not include transportation away from the plant.

Unit values for dimension stone ranged from $11.83 per ton for rubble to $521.53 for slate used for blackboards and averaged $74.55, an increase of 6% over the 1975 average. Values, per cubic foot, were $5.38 for rough monumental stone, $2.62 for rough blocks, $15.47 for cut building stone, $2.14 for rough construction stone, and $5.76 for curbing, averaging $6.16 per cubic foot.

Unit values for crushed stone ranged from $1.25 per ton for waste material to $20.22 for whiting and averaged $2.35 per ton, an increase of 4% over the 1975 average. Values included $2.10 per ton for roadbase aggregate, $2.29 for other aggregate and roadstone, $2.33 for concrete aggregate, $1.78 for stone used in cement, and $2.60 for bituminous aggregate.

Unit values for dimension limestone averaged $47.81 per ton, or $3.60 per cubic foot; crushed limestone averaged $2.26 per ton. Values for dimension granite averaged $97.39 per ton, or $8.84 per cubic foot; crushed granite averaged $2.44 per ton. Values for dimension traprock averaged $12.31 per ton, or $1.05 per cubic foot; crushed traprock averaged $2.56 per ton. Values for dimension sandstone averaged $37.44, per ton or $2.89 per cubic foot; crushed sandstone averaged $2.94 per ton. Values for dimension marble averaged

$184.32 per ton, or $16.18 per cubic foot; crushed marble averaged $14.14 per ton. Values for dimension slate averaged $125.01 per ton, or $11.05 per cubic foot; crushed slate averaged $6.60 per ton. Shell sold for $2.72 per ton and marl for $1.32. Values for miscellaneous dimension stone averaged $36.45 per ton, or $3.01 per cubic foot; other crushed stone averaged $2.33 per ton.

Table 33.—Unit values of stone sold or used by producers in the United States

Stone	1975			1976		
	Dimension stone		Crushed stone, per ton	Dimension stone		Crushed stone, per ton
	Per ton	Per cubic foot		Per ton	Per cubic foot	
Limestone	$43.55	$3.35	$2.13	$47.81	$3.60	$2.26
Granite	89.53	8.29	2.30	97.39	8.84	2.44
Traprock	10.57	1.00	2.46	12.31	1.05	2.56
Sandstone	34.87	2.66	2.85	37.44	2.89	2.94
Marble	190.56	18.24	15.49	184.32	16.18	14.14
Slate	120.34	11.00	6.50	125.01	11.05	6.60
Shell	--	--	3.41	--	--	2.72
Marl	--	--	1.39	--	--	1.32
Miscellaneous	34.44	2.74	2.19	36.45	3.01	2.33
Average	70.27	6.16	2.25	74.55	6.16	2.35

FOREIGN TRADE

Dimension stone was exported all over the world, but mainly to Canada. Exports included 63,000 tons of dimension limestone valued at $1.49 million and 120,000 tons of other dimension stone valued at $2.60 million.

Crushed stone was exported to many countries, mainly to Canada. Exports included 3.19 million tons of crushed limestone valued at $10.5 million and 1.2 million tons of other crushed stone valued at $9.35 million.

Stone was imported from many countries; total value of stone imported was $46.2 million, about the same as in 1975. Imports of dimension stone included 5,000 tons of limestone from Mexico valued at $176,000 82,000 tons of granite, mainly from Canada, Mexico, Taiwan, and Italy, valued at $9.88 million; 258,000 tons of marble, all from Italy, valued at $20.2 million; and 49,000 tons of slate, mainly from Italy and Portugal, valued at $5.88 million.

Imports of crushed stone included 3.60 million tons of limestone, mainly from Canada, Bahamas, and the Dominican Republic, valued at $9.08 million; 11,000 tons of granite from the Republic of South Africa valued at $194,000; and 2,500 tons of marble from Canada valued at $86,000. Total crushed stone imports were 3.69 million tons valued at $10.1 million.

Table 34.—U.S. exports of stone

(Thousand short tons and thousand dollars)

Year	Building and monumental stone			Crushed, ground, or broken				Other manufactures of stone (value)
	Dolomite		Other (value)	Limestone		Other		
	Quantity	Value		Quantity	Value	Quantity	Value	
1974	86	1,559	1,920	2,793	7,753	625	4,850	2,077
1975	49	1,464	2,449	3,386	9,993	896	5,843	2,376
1976	63	1,486	2,596	3,191	10,537	866	7,073	2,273

Table 35.—U.S. imports for consumption of stone and whiting, by class

Class	1975 Quantity	1975 Value (thousands)	1976 Quantity	1976 Value (thousands)
Granite:				
Monumental, paving and building stone:				
Rough ---- cubic feet	243,320	$2,369	227,749	$2,234
Dressed ---- do	r327,983	5,617	193,825	4,669
Not manufactured and not suitable for monumental, paving, or building stone ---- short tons	4,361	156	11,313	127
Other, n.s.p.f	(1)	703	(1)	67
Total	XX	8,845	XX	7,097
Marble, breccia, and onyx:				
In block, rough, or squared ---- cubic feet	14,112	209	17,726	156
Sawed or dressed, over 2 inches thick ---- do	361	8	710	15
Slabs and paving tiles ---- superficial feet	5,183,004	7,663	8,019,528	8,277
All other manufactures	(1)	7,601	(1)	7,344
Total	XX	15,481	XX	15,792
Travertine stone:				
Rough, unmanufactured ---- cubic feet	4,008	19	41,268	103
Dressed, suitable for monumental, paving, and building stone ---- short tons	22,548	2,994	26,469	3,667
Other, n.s.p.f	(1)	447	(1)	248
Total	XX	3,460	XX	4,018
Limestone:				
Monumental, paving, and building stone:				
Rough ---- cubic feet	13,889	24	12,111	19
Dressed, manufactured ---- short tons	3,863	164	580	41
Crude, not suitable for monumental, paving, or building stone ---- do	147,262	579	104,605	492
Other, n.s.p.f	(1)	43	(1)	42
Total	XX	810	XX	594
Slate:				
Roofing ---- square feet	--	--	13,936	4
Other, n.s.p.f	(1)	6,597	(1)	5,880
Total	XX	6,597	XX	5,884
Quartzite ---- short tons	122,245	804	75,404	744
Stone and articles of stone, n.s.p.f.:				
Statuary and sculptures	(1)	366	(1)	354
Stone, unmanufactured ---- short tons	10,610	215	4,532	116
Building stone, rough ---- cubic feet	6,909	11	11,622	15
Building stone, dressed ---- short tons	783	63	1,552	146
Other	(1)	2,235	(1)	2,816
Total	XX	2,890	XX	3,447
Stone, chips, spall, crushed or ground:				
Marble, breccia, and onyx chips ---- short tons	2,522	80	2,503	86
Limestone, chips and spalls, crushed or ground ---- do	1,616,312	2,432	1,580,391	2,376
Stone chips and spalls, and stone crushed or ground, n.s.p.f ---- do	1,371,363	2,764	1,280,573	2,746
Slate chips and spalls, and slate crushed or ground ---- do	353	1	(1)	1
Total	2,990,550	5,277	XX	5,209
Aragonite	492,750	512	573,580	620
Whiting:				
Whiting, dry, ground, or bolted ---- short tons	20,115	1,219	35,920	2,227
Chalk, whiting, precipated ---- do	1,563	242	4,349	579
Total	21,678	1,461	40,269	2,806
Grand total	XX	46,137	XX	46,211

rRevised. XX Not applicable.
1Quantity not reported.

WORLD REVIEW

Stone occurs all over the world. Resources are virtually unlimited, but shortages of stone for certain uses exist. Most stone is produced in the heavily industrialized countries. World output of stone in 1976 was estimated at about 5 billion tons, including 2 billion from Europe, 1.5 billion from Asia, and 1 billion from North America.

Canada.—Production of stone in 1975 was 97 million tons valued at $171 million. Exports of stone, mainly to the United States, were 1.7 million tons valued at $6.1 million. The stone was used for roadmetal (34%), concrete aggregate (19%), asphalt aggregate (7%), railroad ballast (5%), and many other uses. Of the total, 78% was limestone and 15% was granite. Leading Provinces were Quebec (55%) and Ontario (35%).

France.—France ranked behind Italy in output of dimension stone. Production of crushed stone was about 200 million tons, 4%, of the world's output.

Germany, West.—Production of stone in West Germany was estimated at about 250 million tons, 5% of the world total.

Italy.—Italy ranked first in output of dimension stone. Output of crushed stone was estimated at about 100 million tons, 2% of the world total.

Japan.—Japan produced about 180 million tons of stone, 4% of the world total.

U.S.S.R.—The Soviet Union ranked second behind the United States in stone production. Output was estimated at about 500 million tons, 10% of the world's supply of stone.

Sulfur and Pyrites

By John E. Shelton[1]

There was a slight increase in sulfur prices in 1976 compared with those in 1975. The average net shipment value f.o.b. mine/plant for Frasch and recovered elemental sulfur increased 2% from $45.63 per long ton in 1975 to $46.45 per ton in 1976. Both export and import prices decreased. The yearend price for Frasch sulfur was $61 per ton Gulf Ports.

Production of sulfur in all forms in 1976 decreased 4.9% below that of 1975. For the first time in 8 years, production did not equal apparent domestic consumption. Sulfur was produced by 69 companies at 182 operations in 32 States, with 10 companies having 57 operations accounting for 75% of the output. Distribution of production was Frasch sulfur 59%, recovered elemental sulfur 29%, and the contained sulfur in other production 12%. Production was concentrated in Texas and Louisiana. Together, these two States accounted for 68% of the total output.

[1]Supervisory physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient sulfur statistics

(Thousand long tons, sulfur content, and thousand dollars unless otherwise noted)

	1972	1973	1974	1975	1976
United States:					
Production:					
Frasch	7,290	7,605	7,901	7,211	6,264
Recovered elemental	1,950	2,416	2,632	2,969	3,138
Other forms	978	900	886	1,079	1,305
Total	10,218	10,921	11,419	11,259	10,707
Shipments:					
Frasch	7,613	7,438	7,898	6,077	5,860
Recovered elemental	1,927	2,451	2,547	2,902	3,146
Other forms	978	900	886	1,079	1,305
Total	10,518	10,789	11,331	10,058	10,311
Imports, elemental and pyrites	1,188	1,222	2,150	1,897	1,727
Exports, crude and refined	1,852	1,776	2,663	1,352	1,270
Consumption, apparent all forms[1]	9,854	10,235	10,818	10,603	10,768
Stocks, Dec. 31: Producer, Frasch and recovered elemental	3,796	3,927	3,957	5,126	5,563
Value:					
Shipments, f.o.b. mine or plant:					
Frasch	$132,385	$138,578	$241,066	$304,843	$299,999
Recovered elemental	30,060	37,873	60,599	104,886	118,322
Other forms	32,124	31,363	35,422	50,053	59,050
Total	194,569	207,814	337,087	459,782	477,371
Imports, elemental[2]	$16,288	$14,871	$51,124	$70,848	$59,494
Exports, crude[2]	$32,409	$34,330	$95,516	$69,553	$60,226
Price, elemental, dollars per long ton, f.o.b. mine or plant	$17.03	$17.84	$28.88	$45.63	$46.45
World production: All forms (including pyrites)	44,776	47,437	[r]50,345	[r]49,877	49,741

[r]Revised.
[1]Measured by shipments, plus imports, minus exports.
[2]Declared customs valuation.

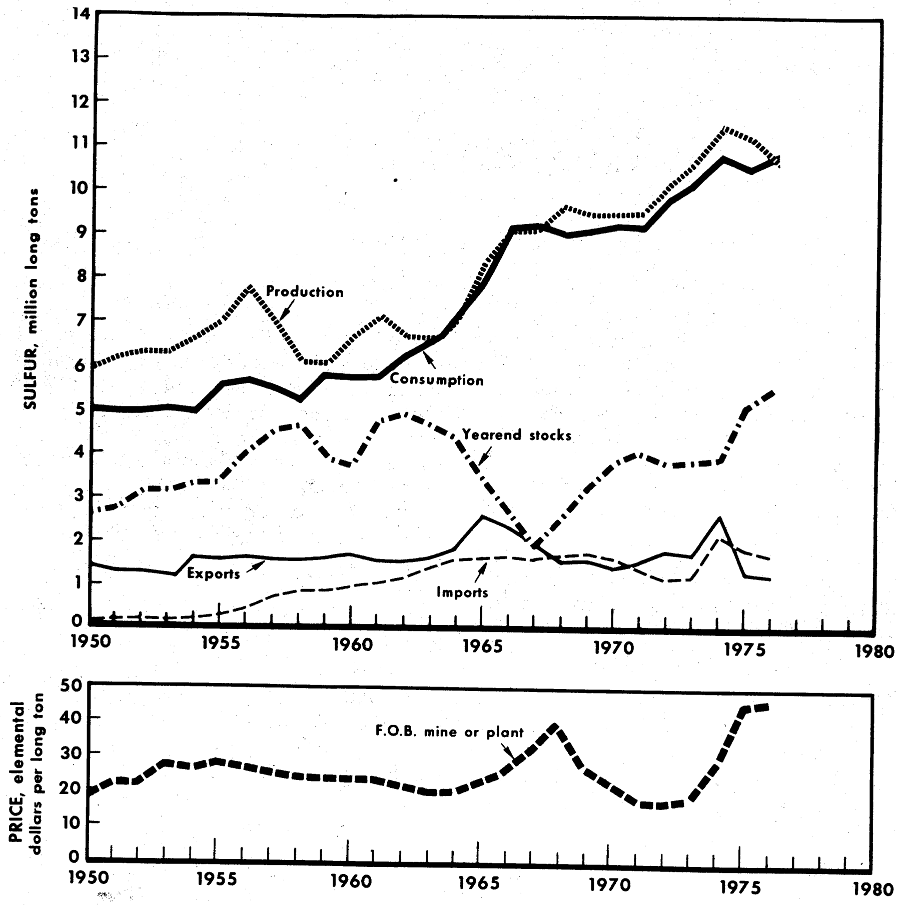

Figure 1.—Trends in the sulfur industry in the United States.

Shipments of sulfur in all forms to domestic and export markets increased 3% above those in 1975. Frasch and elemental sulfur accounted for 87% of the total shipments of sulfur in all forms in 1976. The total value of shipments f.o.b. mine/plant was $477.4 million in 1976 as compared with $459.8 million in 1975, an increase of 4%. Eighty-eight percent of the shipments was for domestic consumption and 12% for export. Shipments of sulfur in all forms in 1976 were 4% less than the quantity produced. Producers' yearend stocks of Frasch and recovered elemental sulfur were almost 9% greater than those at yearend 1975.

The apparent domestic consumption of sulfur in all forms increased 2% over that of 1975. Sulfur for domestic consumption was obtained mainly from domestic sources: Frasch 43%, recovered elemental 29%, and sulfur in other forms 12%. The remaining 16% of the sulfur was obtained by imports of Frasch and recovered elemental sulfur.

The United States was a net importer again in 1976. Exports of sulfur in all forms decreased 6% from 1975. Imports of sulfur in all forms in 1976 were 9% less than in 1975.

DOMESTIC PRODUCTION

Frasch Sulfur.—Output of Frasch sulfur was 59% of the domestic production of sulfur in all forms in 1976 compared with 64% in 1975.

In 1976, there were 12 Frasch mines, all in Texas and Louisiana. Producers and mines in Louisiana were Freeport Minerals Co. at Garden Island Bay, Grand Isle and Grand Ecaille, and Texasgulf, Inc., at Bully Camp. Producers and mines in Texas were Farmland Industries, Inc., who purchased the Atlantic Richfield Co. mine at Fort Stockton on November 1; Duval Corp. at Culberson; Jefferson Lake Sulfur Company at Long Point Dome; and Texasgulf, Inc.at Boling Dome, Fannett Dome, Moss Bluff Dome, Spindletop Dome, and the new mine at Comanche Creek. With the opening of the Comanche Creek mine, capacity to produce sulfur in West Texas will be more than 3 million tons per year.[2]

The ten mines operated by Duval Corp., Freeport Minerals Co., and Texasgulf, Inc., accounted for most of the Frasch sulfur production. A relatively small portion of the output was from the other two producers operating one mine each.

Production was again concentrated in the larger low-cost mines to counteract increasing production costs. The five largest mines, with four having a production rate in excess of one-half million tons per year each, accounted for 82% of the total Frasch sulfur production compared with 84% in 1975. These mines also accounted for 48% of the total output of sulfur in all forms in 1976 compared with 54% in 1975.

Producers' shipments of Frasch sulfur were 4% less than in 1975. Approximately 20% of the total shipments were for export and 80% were for the domestic market compared with 21% and 79%, respectively, in 1975. Because production was greater than shipments, producers' reported stocks after inventory adjustments were 9% greater than at yearend 1975.

Primarily because of the decrease in the quantity of Frasch sulfur shipped, the total value of shipments, f.o.b. mine, decreased almost 2% below that of the alltime reported high of $305 million in 1975.

[2]Sulphur (London). Comanche Creek. Texasgulf's New Texas Mine. No. 122, January-February 1976, pp. 30-31.

Table 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Thousand long tons)

	1973		1974		1975		1976	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Frasch sulfur	7,605	7,605	7,901	7,901	7,211	7,211	6,264	6,264
Recovered elemental sulfur	2,416	2,416	2,632	2,632	2,969	2,969	3,138	3,138
Byproduct sulfuric acid (basis 100%) produced at copper, zinc, and lead plants	1,834	600	2,001	654	2,345	767	2,881	942
Pyrites	559	212	424	162	625	237	750	286
Other forms[1]	107	88	82	70	110	75	116	77
Total	XX	10,921	XX	11,419	XX	11,259	XX	10,707

XX Not applicable.
[1]Hydrogen sulfide and liquid sulfur dioxide.

Table 3.—Sulfur produced and shipped from Frasch mines in the United States

(Thousand long tons and thousand dollars)

Year	Production			Shipments	
	Texas	Louisiana	Total	Quantity	Value[1]
1972	3,755	3,534	[2]7,290	7,613	132,385
1973	4,294	3,311	7,605	7,438	138,578
1974	4,593	3,308	7,901	7,898	241,066
1975	4,141	3,070	7,211	6,077	304,843
1976	3,777	2,487	6,264	5,860	299,999

[1]F.o.b. mine.
[2]Data do not add to total shown because of independent rounding.

Recovered Sulfur.—Production of recovered elemental sulfur, a nondiscretionary byproduct from natural gas and petroleum refinery operations, accounted for 29% of the total domestic production of sulfur in all forms compared with 26% in 1975. Production and shipments reached an alltime high with increases of 6% and 8%, respectively, over those of 1975, indicating the continuing increase in importance of recovered sulfur as a source of domestic supply. This type of sulfur was produced by 51 companies at 137 plants in 27 States, 2 plants in Puerto Rico, and 1 in the Virgin Islands. Most of the plants were of relatively small size, with only four reporting an annual production exceeding 100,000 tons. The 10 largest plants accounted for 37% of the output, and the combined production from the 5 leading States was 66% of the total. By source, 59% was produced by 38 companies at 79 refineries or satellite plants treating refinery gases, and 1 coking operation, and 41% was produced by 24 companies at 57 natural gas treatment plants. The five largest recovered elemental sulfur producers were Chevron, U.S.A., Inc., Exxon Co., U.S.A., Getty Oil Co., Shell Oil Co., and Standard Oil Co. (Indiana). Together, their 41 plants accounted for 53% of recovered elemental sulfur production in 1976.

The total value of shipments of recovered elemental sulfur in 1976 increased 13% to an alltime high of almost $118 million.

The leading States in production of recovered elemental sulfur were Texas, California, Florida, Mississippi, and Alabama.

Table 4.—Recovered sulfur produced and shipped in the United States

(Thousand long tons and thousand dollars)

Year	Production			Shipments	
	Natural gas plants	Petroleum refineries	Total[1]	Quantity	Value[2]
1972	819	1,131	1,950	1,927	30,060
1973	1,046	1,370	2,416	2,451	37,873
1974	1,219	1,414	2,632	2,547	60,599
1975	1,342	[3]1,627	2,969	2,902	104,886
1976	1,277	[3]1,860	3,138	3,146	118,322

[1]Data may not add to totals shown because of independent rounding.
[2]F.o.b. plant.
[3]Includes a small quantity from coking operations.

Table 5.—Recovered sulfur produced and shipped in the United States, by State

(Thousand long tons and thousand dollars)

State	1975			1976		
	Production (quantity)	Shipments		Production (quantity)	Shipments	
		Quantity	Value		Quantity	Value
Alabama	205	206	8,025	206	206	9,441
Arkansas	18	18	677	W	W	W
California	395	375	6,949	432	432	7,940
Florida	285	285	W	307	308	W
Illinois and Indiana	203	199	6,792	220	223	7,470
Kansas	10	10	291	7	7	253
Louisiana	90	91	4,311	123	122	6,228
Michigan and Minnesota	55	55	1,977	60	58	1,867
Mississippi	312	298	13,425	245	224	11,264
New Jersey	83	83	3,709	107	108	5,043
New Mexico	28	27	974	45	45	1,480
Ohio	15	15	640	16	17	714
Oklahoma	8	8	239	9	9	324
Pennsylvania	68	68	2,551	91	91	3,876
Texas	801	796	29,072	872	872	34,397
Wisconsin	1	1	10	([1])	([1])	3
Wyoming	52	39	W	44	51	W
Other States[2]	339	327	25,246	352	374	28,021
Total[3]	2,969	2,902	104,886	3,138	3,146	118,322

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1]Less than 1/2 unit.
[2]Combined to avoid disclosing individual company confidential data; includes Colorado (1975), Delaware, Missouri, Montana, New York, North Dakota, Utah, Virginia, Washington, Virgin Islands, and Puerto Rico.
[3]Data may not add to totals shown because of independent rounding.

Together these States contributed 66% of the total 1976 output. Production in 1976 increased compared with 1975 by 9% each in California and Texas and 8% in Florida. The production rate in Alabama was essentially unchanged whereas it dropped 21% in Mississippi. Recovery of sulfur in Alabama, Florida, and Mississippi was mainly from the treatment of dry sour natural gas and sour natural gas associated with petroleum in the deep Jurassic formations. Indications were of further increases in sulfur recovery in future years.

Byproduct Sulfuric Acid.—Sulfur contained in byproduct sulfuric acid produced at copper, lead, and zinc smelters and roasters during 1976 was 9% of the total domestic production of sulfur in all forms compared with 7% in 1975. The total output and value reached an alltime high in 1976. In

Table 6.—Byproduct sulfuric acid[1] (sulfur content) produced in the United States

(Thousand long tons and thousand dollars)

Year	Copper plants[2]	Lead and zinc plants[3]	Total	Value
1972	295	251	546	22,897
1973	318	282	600	24,175
1974	373	281	654	29,370
1975	521	246	767	42,956
1976	666	276	942	46,181

[1]Includes acid from foreign materials.
[2]Excludes acid made from pyrites concentrates.
[3]Excludes acid made from native sulfur.

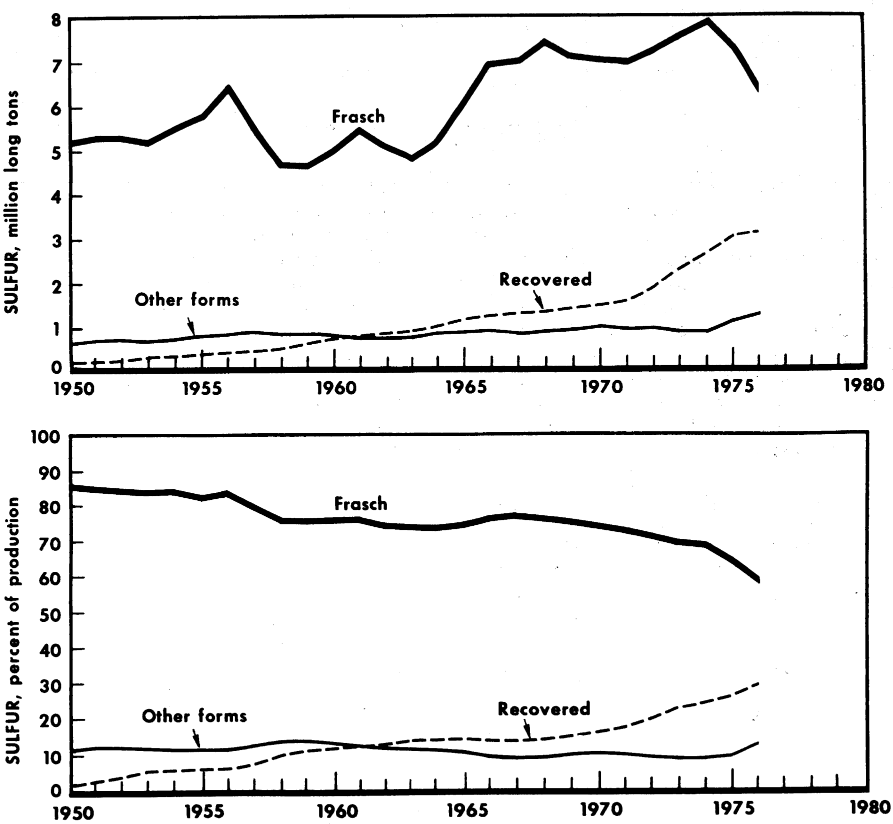

Figure 2.—Trends in the production of sulfur in the United States.

1976, output was 23% higher and total value was 8% higher than in 1975. Byproduct sulfuric acid was produced by 13 companies at 24 plants in 13 States. Fourteen acid plants operated in conjunction with copper smelters and 10 plants were accessories to lead and zinc roasting and smelting operations. The five largest acid plants accounted for 44% of the output, and production in five States was 79% of the total. The five largest producers of byproduct sulfuric acid were ASARCO Incorporated, Magma Copper Co., Kennecott Copper Corp., Phelps Dodge Corp., and St. Joe Minerals Corp., whose 14 plants produced 71% of the byproduct sulfuric acid in 1976.

Pyrites, Hydrogen Sulfide, and Sulfur Dioxide.— Sulfur contained in pyrites, hydrogen sulfide, and sulfur dioxide represented 3% of the total production of sulfur, unchanged from 1975. The total sulfur content in these products was 16% more than that of 1975, and the value of shipments was 81% higher. Pyrites was produced by three companies at three mines in three States, hydrogen sulfide by three companies at four plants in three States; and sulfur dioxide by two companies at two plants in two States. The three largest producers of these products were Cities Service Co., (pyrites, and sulfur dioxide), ASARCO Incorporated (sulfur dioxide), and Shell Oil Co. (hydrogen sulfide). These companies combined, at one mine and four plants, accounted for 94% of the contained sulfur produced in the form of these products.

Table 7.—Pyrites, hydrogen sulfide, and sulfur dioxide sold or used in the United States

(Thousand long tons sulfur content and thousand dollars)

Year	Pyrites	Hydrogen sulfide and sulfur dioxide	Total	Value
1972	283	149	432	9,227
1973	212	88	300	7,188
1974	162	70	232	6,052
1975	237	75	312	7,097
1976	286	77	363	12,869

CONSUMPTION AND USES

In 1976, apparent domestic consumption of sulfur in all forms was 10.8 million tons, 2% greater than in 1975. Eighty-four percent of this consumption was from domestic sources compared with 82% in 1975. The supply sources of sulfur were domestic Frasch sulfur 43% compared with 45% in 1975, domestic recovered elemental sulfur 29% compared with 27% in 1975 and combined domestic byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide 12% compared with 10% in 1975. The remaining 16% of the sulfur was from imports of Frasch and recovered elemental sulfur compared with 18% in 1975.

The apparent sales of domestic Frasch sulfur to domestic consumers decreased by 120,000 tons, or 3% below shipments in 1975. Apparent shipments of recovered elemental sulfur for domestic consumption increased by 229,000 tons, or 8% over those in 1975. Reported sales of the sulfur content of byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide increased 226,000 tons or 21% above those in 1975. Total supplies of domestic sulfur in all forms to the domestic market increased by 335,000 tons. Imports of Frasch and recovered elemental sulfur decreased 170,000 tons or 9% below those of 1975. By source, imports of Frasch sulfur from Mexico decreased 236,000 tons; while imports of recovered elemental sulfur from Canada increased 39,000 tons and from other countries by almost 27,000 tons.

The Bureau of Mines initiated a survey to collect data on the end uses of sulfur and sulfuric acid by Standard Industrial Classification (SIC) of industrial activities. Canvass forms were sent to producers for data on shipments by end uses. In 1975 and 1976, 58 elemental sulfur and 77 sulfuric acid producing companies responded to the canvass. Of the above companies 17 reported shipments of both sulfur and sulfuric acid.

Producers of sulfur who responded to the canvass reported shipments of 10.6 million long tons of sulfur in 1975 and 10.5 million long tons in 1976. Of these reported shipments 1.2 million tons each year were for export. The largest use was 7.6 million tons in 1975 and 7.9 million tons in 1976 for sulfuric acid. This represented 81% and 84%, respectively, of shipments for domestic consumption in 1975 and 1976. Other reported end uses for elemental sulfur were industrial inorganic chemicals; synthetic rubber, cellulosic fibers and other plastic products; paints and allied products, explosives, industrial organic chemicals and other chemical products; petroleum refining and petroleum and coal products; pulp and paper products and agricultural chemicals which showed little change as a percentage of total domestic uses. Some companies did not identify shipments by end use. Some identified end uses were tabulated in the unidentified uses because of company confidentiality.

Of the reported shipments of 32.8 million short tons in 1975 and 33.6 million short tons in 1976 of 100% sulfuric acid, the largest end use was for phosphatic fertilizers. Shipments were 19 million tons or 58% of the total in 1975 and 19.7 million tons or 59% of the total in 1976. Shipments for other chemical products were 2.9 million tons or 9% of the total in both years. Petroleum refining and other petroleum and coal production received 2 million tons of acid or 6% in each year. The petroleum refining industry was a net user of about 700,000 tons of sulfuric acid however, since 1.3 million tons of spent acid were returned each year for reclaiming.

Usage of acid for copper ore leaching increased from 1.4 million tons in 1975 to 1.8 million tons in 1976, 4% and 5%, respectively, each year of the total shipments. Shipments for other categories are shown in table 10. Several end uses for sulfuric acid such as food products, automotive, electrical equipment, rubber and metal fabrication were tabulated in "Unidentified" because of confidentiality.

Of the total of 2.1 million short tons in 1975 and 2.4 million short tons in 1976 of spent acid returned for reclaiming, 175,000 tons or 9% in 1975 and 186,000 tons or 8% in 1976 were from the production of industrial organic chemicals. Petroleum refineries accounted for 61% in 1975 and 54% in 1976 of the total spent acid returned for reclaiming. The remaining reclaimed acid was from production of plastic materials, nonferrous metals, phosphatic fertilizers, paints and allied products, other chemical products, inorganic pigments, soaps and detergents, explosives, other agricultural chemicals, and organic chemicals.

Table 11 shows the total domestic use of sulfur including the sulfur content of sulfuric acid. The largest identified end use for sulfur (mostly as sulfuric acid) was the 49% in 1975 and 51% in 1976 for phosphatic fertilizers. Other uses were for other chemical products, 8% each year, petroleum refining and other petroleum and coal products, 6% each year and other inorganic chemicals, 5% each year. Sulfur used for copper ore processing (as sulfuric acid) increased 35% from 396,000 tons, 3% of the total in 1975 to 533,000 tons, 5% of the total in 1976.

Table 8.—Apparent consumption of sulfur in the United States[1]

(Thousand long tons)

	1972	1973	1974	1975	1976
Frasch:					
Shipments	7,613	7,438	7,898	6,077	5,860
Imports	269	302	954	967	731
Exports	1,852	1,776	2,601	1,295	1,198
Total	6,030	5,964	6,251	5,749	5,393
Recovered:					
Shipments	1,927	2,451	2,547	2,902	3,146
Imports	869	920	1,196	930	996
Exports from the Virgin Islands	--	--	62	57	72
Total	2,796	3,371	3,681	3,775	4,070
Pyrites:					
Shipments	283	212	162	237	286
Imports[e]	50	--	--	--	--
Total	333	212	162	237	286
Byproduct sulfuric acid	546	600	654	767	942
Other forms[2]	149	88	70	75	77
Total all forms	9,854	10,235	10,818	10,603	10,768

[e]Estimate.
[1]Crúde sulfur or sulfur content.
[2]Includes consumption of hydrogen sulfide and liquid sulfur dioxide.

Table 9.—Elemental sulfur sold or used in the United States, by end use

(Thousand long tons)

SIC	Use	1975	1976
20	Food and kindred products	3	4
26	Pulp and paper products	102	110
282,2822, 2823	Synthetic rubber, cellulosic fibers and other plastic products	129	85
287	Agricultural chemicals	90	88
28,285, 2892,286	Paints and allied products, explosives, industrial organic chemicals, and other chemical products	[1]129	[1]88
29	Petroleum refining and petroleum and coal products	121	84
281	Other industrial chemicals	231	337
30	Rubber and miscellaneous plastic products	([2])	10
	Sulfuric acid:		
	Domestic sulfur	6,689	7,047
	Imported sulfur	874	873
	Total sulfuric acid	7,563	7,920
	Unidentified	978	660
	Total domestic uses	9,346	9,386
	Exports	1,240	1,169
	Total	10,586	10,555

[1]Includes explosives 1975, and industrial organic chemicals 1976.
[2]Included in Unidentified.

Table 10.—Sulfuric acid sold or used in the United States, by use

(Thousand short tons of 100% H_2SO_4)

SIC	Use	Quantity	
		1975	1976
102	Copper ores	1,358	1,829
1094	Uranium and vanadium ore	302	309
10	Other ore	14	11
261	Pulp mills	429	511
26	Other paper products	40	43
285,2816	Inorganic pigments and paints and allied products	758	600
281	Other inorganic chemicals	953	783
282,2822	Synthetic rubber and other plastic materials and synthetics	390	408
2823	Cellulosic fibers including rayon	372	359
283	Drugs	136	127
284	Soaps and detergents	374	393
286	Industrial organic chemicals	443	470
2873	Nitrogenous fertilizers	552	494
2874	Phosphatic fertilizers	19,043	19,696
2879	Pesticides	28	18
287	Other agricultural chemicals	248	305
2892	Explosives	139	109
2899	Water treating compounds	289	272
28	Other chemical products	2,947	2,895
29,291	Petroleum refining and other petroleum and coal products	2,058	2,026
331	Steel pickling	358	325
333	Nonferrous metals	39	60
33	Other primary metals	11	11
3691	Storage batteries/acid	114	114
	Unidentified	1,328	1,381
	Total domestic[1]	32,724	33,550
	Exports	120	28
	Total	32,844	33,578

[1]Data may not add to totals shown because of independent rounding.

Table 11.—Sulfur and sulfuric acid sold or used in the United States, by end use

(Thousand tons sulfur content)

SIC		Elemental sulfur[1]		Sulfuric acid (sulfur equivalent)		Total	
		1975	1976	1975	1976	1975	1976
102	Copper ores	--	--	396	533	396	533
1094	Uranium and vanadium ores	--	--	88	90	88	90
10	Other ores	--	--	4	3	4	3
20	Food and kindred products	3	4	--	--	3	4
261,26	Pulpmills and paper products	102	110	137	162	239	272
2816,285 2892,28,286	Inorganic pigments, paints and allied products, explosives, industrial organic chemicals, and other chemical products	[2]129	[2]88	221	175	[2]350	[2]263
281	Other inorganic chemicals	231	337	278	228	509	565
2822, 2823,282	Synthetic rubber, cellulosic fibers, other plastic materials and synthetics	129	85	222	224	351	309
283	Drugs	--	--	40	37	40	37
284	Soaps and detergents	--	--	109	115	109	115
286	Industrial organic chemicals	--	--	129	137	129	137
2873	Nitrogenous fertilizers	--	--	161	144	161	144
2874	Phosphatic fertilizers	--	--	5,552	5,741	5,552	5,741
2879	Pesticides	--	--	8	5	8	5
287	Other agricultural chemicals	90	88	72	89	162	177
2892	Explosives	--	--	41	32	41	32
2899	Water treating compounds	--	--	84	79	84	79
28	Other chemical products	--	--	859	844	859	844
291,29	Petroleum refining and other petroleum and coal products	121	84	600	591	721	675
30	Rubber and miscellaneous plastic products	([3])	10	([3])	([3])	([3])	10
331	Steel pickling	--	--	104	95	104	95
333	Nonferrous metals	--	--	11	17	11	17
33	Other primary metals	--	--	3	3	3	3
3691	Storage batteries	--	--	33	33	33	33
	Exported sulfuric acid	--	--	35	8	35	8
	Subtotal	805	806	9,187	9,385	9,992	10,191
	Unidentified	978	660	387	403	1,365	1,063
	Total	1,783	1,466	9,574	9,788	11,357	11,254

[1]Does not include elemental sulfur used for production of sulfuric acid.
[2]Includes explosives (1975), and industrial organic chemicals (1976).
[3]Included in "Unidentified."

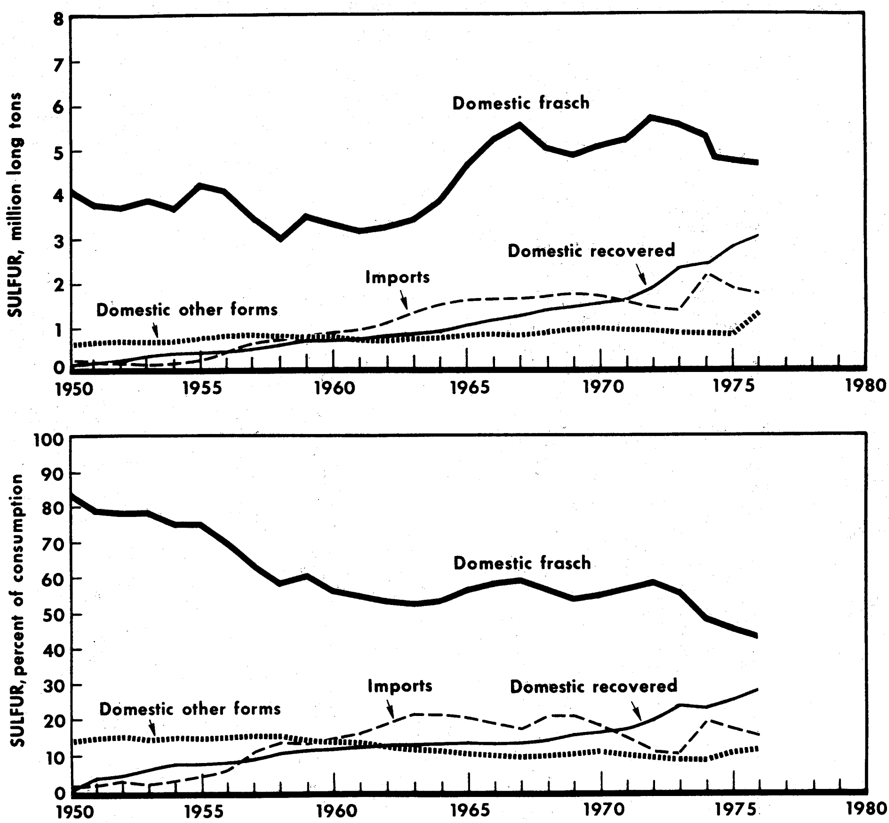

Figure 3.—Trends in the consumption of sulfur in the United States.

STOCKS

Producers' stocks of Frasch plus recovered elemental sulfur, after inventory adjustments, increased 9% over inventories at yearend 1975. Frasch sulfur stocks increased 9%; whereas recovered elemental sulfur stocks decreased 1%. The combined yearend stocks amounted to approximately 7.4 months supply based on 1976 domestic and export demands for domestically produced Frasch and recovered elemental sulfur.

Table 12.—Producers' yearend stocks

(Thousand long tons)

Year	Frasch	Recovered	Total
1972	3,665	131	3,796
1973	3,816	111	3,927
1974	3,744	213	3,957
1975	4,857	269	5,126
1976	5,297	266	5,563

PRICES

The quoted price for liquid sulfur exterminal Tampa, Fla., was $61 to $65 per long ton at yearend 1976 compared with $65 per ton at yearend 1975. There were price decreases in other markets.

On the basis of shipments and total value reported to the Bureau of Mines, the average value of shipments of Frasch sulfur f.o.b. mine for both domestic consumption and exports during 1976 rose to $51.19 per ton compared with $50.16 per ton in 1975 an increase of 2%. The recovered elemental sulfur industry was in a less favorable marketing position to obtain full benefit of the higher sulfur prices. This market was subject to regional competitive forces. Also, as a nondiscretionary byproduct there was a general tendency to sell sulfur in local markets. Sales were more dependent upon the industrial sector of the market. Shipment values varied widely in different regions; lowest in the West, somewhat higher in the midcontinent, and near the values for Frasch sulfur in the East and South. Overall, the reported unit shipment values f.o.b. plant in 1976 were $37.61 per ton, up 4% from $36.14 per ton in 1975.

Marketing sulfur produced in other than the elemental form reflected competitive positions in the limited regional markets for these products. In 1976, shipments of sulfur contained in byproduct sulfuric acid decreased $6.99 per ton of contained sulfur or 12%; whereas, the unit value for sulfur contained in pyrites, hydrogen sulfide, and sulfur dioxide increased $12.70 or 56% compared with 1975.

Table 13.—Reported sales values of shipments of elemental sulfur, f.o.b. mine or plant

(Dollars per long ton)

Year	Frasch	Recovered	Total
1972	17.39	15.60	17.03
1973	18.63	15.45	17.84
1974	30.52	23.79	28.88
1975	50.16	36.14	45.63
1976	51.19	37.61	46.45

FOREIGN TRADE

The United States was a net importer of sulfur in 1976, for the second year. Exports were down 6% to less than 1.3 million tons. Imports in the form of elemental sulfur decreased 9% to 1.7 million tons. The net import balance in 1976 was 457,000 tons compared with a net import of 545,000 tons in 1975.

Exports from the United States were almost entirely in the form of Frasch sulfur. The tonnage of crude sulfur exported in 1976 was 8% less than in 1975. Exports of refined sulfur more than doubled. The total value of exports declined 11% below that of 1975. The reported average export value was $53.08 per ton in 1976 compared with $55.44 in 1975 a decrease of 4%. Belgium-Luxembourg and the Netherlands received 75% of the exports, mainly for transshipment to other European Community Countries. Brazil was the third largest customer, receiving 10% of the exports. Not included in the above were exports from the Virgin Islands which were 72,000 tons valued at $3.5 million in 1976.

Imports of Frasch sulfur from Mexico decreased from 967,000 tons in 1975 to 731,000 tons in 1976. Imports of recovered elemental sulfur mostly from Canada increased 7%. Imports from Canada totaled 969,000 tons and imports from Japan were 26,000 tons. The unit value of imports of sulfur from Canada declined $4.71 to $18.30, whereas imports from Mexico increased $5.50 to $56.60 in 1976.

Table 14.—U.S. exports of sulfur

(Thousand long tons and thousand dollars)

Year	Crude		Refined	
	Quantity	Value	Quantity	Value
1972	1,847	32,409	5	1,278
1973	1,771	34,330	5	1,461
1974[1]	2,580	95,516	21	1,829
1975[1]	1,288	69,553	7	2,248
1976[1]	1,183	60,226	15	3,358

[1]Excludes exports from the Virgin Islands to foreign countries: 1974—61,556 long tons ($1,891,142); 1975—56,632 long tons ($3,172,094); 1976—71,643 long tons ($3,516,220); See table 16.

Table 15.—U.S. exports of crude sulfur, by country

(Thousand long tons and thousand dollars)

Destination	1975		1976	
	Quantity	Value	Quantity	Value
Algeria	11	770	--	--
Argentina	26	1,557	21	1,122
Belgium-Luxembourg	449	23,589	599	30,019
Brazil	186	11,475	118	6,539
Canada	48	1,234	58	1,813
Chile	(1)	1	(1)	16
Colombia	1	28	1	66
France	16	600	--	--
Germany, West	(1)	7	(1)	4
Greece	35	2,017	23	1,341
Honduras	(1)	3	1	60
Israel	45	2,578	--	--
Italy	43	2,459	--	--
Jamaica	1	50	--	--
Mexico	1	37	3	70
Netherlands	358	19,663	283	15,249
New Zealand	42	1,850	51	2,616
Peru	3	183	7	379
South Africa, Republic of	(1)	2	(1)	6
Spain	--	--	6	266
Thailand	11	670	--	--
United kingdom	2	110	--	--
Uruguay	10	641	7	400
Other	(1)	r29	5	260
Total	1,288	69,553	1,183	60,226

rRevised.
1Less than 1/2 unit.
2Excludes exports from the Virgin Islands to foreign countries: 1975—56,632 long tons ($3,172,094); 1976—71,643 long tons ($3,516,220); See table 16.

Table 16.—Sulfur exported from the Virgin Islands to foreign countries

(Thousand long tons and thousand dollars)

Country	1975		1976	
	Quantity	Value	Quantity	Value
Argentina	10	558	--	--
Brazil	13	774	22	937
France	11	489	--	--
Italy	9	518	10	461
Jamaica	3	192	2	68
South Africa, Republic of	11	641	38	2,050
Total	57	3,172	72	3,516

Table 17.—U.S. imports of sulfur[1]

(Thousand long tons and thousand dollars)

Year	Elemental		Pyrites[2]	
	Quantity	Value	Quantity	Value
1972	1,138	16,288	50	NA
1973	1,222	14,871	--	--
1974	2,150	51,124	--	--
1975	1,897	70,848	--	--
1976	1,727	59,494	--	--

1Crude sulfur or sulfur content.
2From Canada.

Table 18.—U.S. imports of elemental sulfur, by country

(Thousand long tons and thousand dollars)

Country	1975		1976	
	Quantity	Value	Quantity	Value
Canada	930	21,398	969	17,728
Germany, West	(1)	33	(1)	20
Japan	--	--	26	343
Mexico	967	49,417	731	41,378
Other	--	--	1	25
Total	1,897	70,848	1,727	59,494

1Less than 1/2 unit.

WORLD REVIEW

World production of sulfur decreased slightly in 1976. Following the pattern for the past several years, production of sulfur in all forms continued to exceed demand. World producers' stocks increased more than 3 million tons, primarily in Canada where stocks increased about 2.5 million tons.

Canada.—Production of sulfur in all forms totaled 7.2 million tons in 1976, down from 7.4 million tons in 1975. Recovered elemental sulfur produced at sour natural gas plants, refineries and tar-sand operations represented 89%. Sulfur contained in byproduct sulfuric acid produced at nonferrous metal smelters accounted for the remaining 11%.

In 1976, 45 sour natural gas plants, 42 in Alberta, 2 in British Columbia, and 1 in Saskatchewan were operated with a combined capacity of 9.5 million tons. Production from smelter gases was 767,000 tons of contained sulfur in sulfuric acid, an increase of 12% from 1975. Smelter gases will continue to increase as a source of sulfur, likely doubling by 1985.[3]

Production of sulfur from the Province of Alberta declined 2% to 6.3 million tons in 1976. Shipments increased from 3.8 million tons to 3.9 million tons in 1976. Of these shipments 2.4 million tons was to offshore foreign markets other than the United States, up from 2.2 million tons in 1975. Producers' stocks rose to 18.5 million tons at the end of 1976 up from 16.1 million tons at the end of 1975.

The value of marketed sulfur f.o.b. plant was $16.21 in December 1976 down from $19.24 in December 1975.[4]

A sulfur slating facility, with an annual capacity of 1.2 million tons, was opened by Shell Canada at the Waterton gas processing plant.

The Athabasca tar sands in Alberta, Canada, have been estimated to contain 300 million tons of economically exploitable reserves of sulfur if the tar sands are mined by open pit techniques.[5]

Cyprus.—Production of pyrite in Cyprus was 97,000 tons (sulfur content) in 1975, and about 93,000 tons in 1976. Exports in 1975 were 98,000 tons.

France.—Production of sulfuric acid increased about 8% in 1976.

Production of sulfur from the sour natural gas at the Lacq deposit has placed France among the major world sulfur producers. Annual production of 1.7 to 1.8 million tons are from reserves of recoverable sulfur estimated at 60 million tons in 1970.[6]

Japan.—Capacity to produce recovered elemental sulfur from imported oil increased from 900,000 long tons in 1971 to 1.9 million tons in 1975. During the same period production increased from 305,000 tons to 775,000 tons. Since demand for elemental sulfur is less than production, a storage problem has resulted which has created a problem for Japanese producers who are not permitted to store sulfur in bulk form. Therefore Japanese producers have been searching for export markets.[7]

Elemental sulfur recovered at petroleum refineries was 980,000 long tons in 1976. Sulfur content of pyrite and pyrrhotite ores and concentrates produced in 1976 was 463,000 tons.

Mexico.—Production of Frasch sulfur was 2.0 million tons in 1976 about the same as in 1975. Output of recovered elemental sulfur was 95,000 tons in 1976.

Poland.—Exports of Polish sulfur to market economy countries increased slightly to about 1.6 million tons. Exports to the rest of the world increased about 25% to 1.9 million tons, as European sulfuric acid markets improved.

U.S.S.R.—Production of sulfuric acid increased about 8% to 19.7 million long tons.

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[3]Pearse, G. H. K., Sulphur, Canadian Mineral Survey, 1976. February 1977, pp. 65-66.

[4]Energy Resources Conservations Board, Province of Alberta, Canada. Summary of Monthly Statistics, Alberta Energy Resource Industries. December 1976, p. 10.

[5]Sulphur (London). Canadian Tar Sands, Slower Pace of Development. No. 124, May-June 1976, pp. 28-33.

[6]Sulphur (London). SNPA's Lacq Complex. No. 122, January-February 1976, pp. 35-40.

[7]Sulphur (London). The Japanese Sulphur Surplus. No. 126, September-October 1976, pp. 32-36.

Table 19.—Sulfur: World production in all forms, by country and source

(Thousand long tons)

Country[1] and source[2]	1974	1975	1976[p]
Algeria:			
Pyrite	(3)	--	--
Byproduct, petroleum and natural gas	15	10	10
Total	r15	10	10
Argentina:			
Native (caliche)	25	10	e20
Byproduct, all sources	r22	22	25
Total	r47	32	e45
Australia[4]:			
Pyrite[5]	106	104	102
Byproduct:			
Metallurgy[6]	r138	137	153
Petroleum	8	9	10
Total	r252	250	265
Austria:			
Byproduct:			
Metallurgy	7	8	8
Petroleum and natural gas	15	17	18
Spent oxide	1	--	--
Gypsum	26	28	23
Total	49	53	49
Bahamas: Byproduct, petroleum	--	10	5
Bahrain: Byproduct, petroleum	10	24	10
Belgium: Byproduct, all sources[7]	r219	193	239
Bolivia[8]: Native[9]	41	22	15
Botswana: Byproduct, metallurgy	6	--	--
Brazil[4 10]: Byproduct, petroleum	9	19	e25
Bulgaria:			
Pyrite[e]	r105	r105	110
Byproduct, all sources[e]	r138	r140	153
Total[e]	r243	r245	263
Canada:			
Pyrite	24	10	15
Byproduct:			
Metallurgy	r653	684	767
Natural gas	6,840	6,469	6,102
Petroleum	160	170	197
Tar sands	95	84	98
Total	r7,772	7,417	7,179
Chile[8]:			
Native:			
Refined	7	5	16
Caliche	r25	16	1
Byproduct, metallurgy	23	26	29
Total	r55	47	46
China, People's Republic of:			
Native[e]	130	130	150
Pyrite[e]	r880	r880	885
Byproduct, all sources[e]	120	120	315
Total[e]	r1,130	r1,130	1,350
Colombia:			
Native	30	30	e30
Byproduct, petroleum and natural gas	3	2	2
Total	33	32	e32
Cuba:			
Pyrite[e]	20	20	20
Byproduct, petroleum[e]	8	8	8
Total[e]	r28	r28	28

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source —Continued

(Thousand long tons)

Country[1] and source[2]	1974	1975	1976[p]
Cyprus[11 12]: Pyrite	r80	97	93
Czechoslovakia:			
Native	7	10	e10
Pyrite	r131	66	e85
Byproduct, all sources	17	e50	e50
Total	r155	e126	e145
Denmark: Byproduct, petroleum	5	9	10
Ecuador:			
Native	r5	(13)	e2
Byproduct:			
Natural gas[e]	r3	3	3
Petroleum[e]	r1	1	1
Total[e]	r9	4	6
Egypt[4 10]: Byproduct, petroleum and natural gas	3	4	5
Finland:			
Native[14]	(3)	--	--
Pyrite	335	r e327	e313
Byproduct:			
Metallurgy	341	341	360
Petroleum[e]	r10	15	25
Total[e]	r686	683	698
France: Byproduct:			
Natural gas[15]	r1,823	1,764	1,709
Petroleum[15]	r105	91	87
Unspecified[16]	r140	107	143
Total	r2,068	1,962	1,939
Germany, East:			
Pyrite[e]	57	57	57
Byproduct sources[17]	r343	349	364
Total[e]	r400	406	421
Germany, West:			
Pyrite	211	217	229
Byproduct:			
Metallurgy[18]	r381	355	384
Natural gas[15]	r405	378	453
Petroleum[15]	r59	112	117
Unspecified	r228	199	159
Total	r1,284	1,261	1,342
Greece:			
Pyrite	r103	19 73	e 19 105
Byproduct, petroleum[e]	3	3	3
Total[e]	r106	76	108
Hungary:			
Pyrite[e]	3	3	3
Byproduct, all sources	9	9	e9
Total[e]	12	12	12
India[4]:			
Pyrite	13	19	19
Byproduct:			
Metallurgy[e]	133	138	125
Petroleum	e6	6	7
Total[e]	152	163	151

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source —Continued

(Thousand long tons)

Country[1] and source[2]	1974	1975	1976[p]
Indonesia[12]: Native	2	4	3
Iran[e]:			
Native[e]	20	20	20
Byproduct, petroleum and natural gas	595	467	393
Total[e]	615	487	413
Iraq:			
Frasch	600	591	600
Byproduct petroleum and natural gas[e]	[r]49	[r]108	64
Total[e]	[r]649	699	664
Ireland:			
Pyrite	27	[e]32	[e]30
Byproduct, all sources	([3])	--	--
Total	27	[e]32	[e]30
Israel: Byproduct petroleum and natural gas	8	10	10
Italy:			
Native	60	50	37
Pyrite[e]	[r]506	416	368
Byproduct, all sources[e 20]	[r]210	225	196
Total	[r]776	691	601
Japan:			
Native	([3])	([3])	--
Pyrite	[r]616	530	463
Byproduct:			
Metallurgy[21]	[r]1,397	1,145	1,162
Petroleum[22]	[r]752	775	980
Total	[r]2,765	2,450	2,605
Korea, North:			
Pyrite[e]	[r]240	[r]255	275
Byproduct, metallurgy[e]	[r]16	[r]16	30
Total	[r]256	[r]271	305
Korea, Republic of:			
Pyrite	([13])	([13])	([13])
Byproduct:			
Metallurgy[e]	15	20	22
Petroleum[e]	--	10	25
Total[e]	[r]15	30	47
Kuwait: Byproduct, petroleum and natural gas	56	72	74
Libya: Byproduct, petroleum and natural gas[e]	20	20	20
Mexico:			
Frasch	[r]2,222	2,041	2,021
Byproduct:			
Metallurgy[e]	[r]64	89	95
Petroleum and natural gas	[r]26	51	74
Total[e]	[r]2,312	2,181	2,190
Morocco: Pyrite	155	62	23
Netherlands: Byproduct:			
Metallurgy[e]	30	40	39
Petroleum[e]	54	65	64
Total	84	105	103
Netherlands Antilles: Byproduct, petroleum	[r]115	86	93

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source —Continued

(Thousand long tons)

Country[1] and source[2]	1974	1975	1976[p]
Norway:			
Pyrite	309	229	[e]178
Byproduct:			
Metallurgy[e]	[r]44	[r]39	40
Petroleum[e]	[r]3	[r]5	7
Total	[r]356	273	[e]225
Pakistan:			
Native	2	1	2
Byproduct, all sources	12	12	12
Total	[r]14	13	14
Peru: Byproduct, all sources	19	16	16
Philippines: Pyrite	75	74	102
Poland[23]:			
Frasch[e]	[r]3,600	4,253	4,272
Native[e]	[r]428	443	541
Byproduct:			
Metallurgy[e 24]	[r]223	226	231
Petroleum[e 24]	[r]23	25	25
Gypsum[e]	52	54	54
Total[e]	[r]4,326	5,001	5,123
Portugal:			
Pyrite	[r]218	197	178
Byproduct:			
Metallurgy	2	[e]1	[e]1
Petroleum	1	2	[e]2
Total	[r]221	[e]200	[e]181
Rhodesia, Southern:			
Pyrite[e]	30	30	30
Byproduct coal and/or metallurgy[e]	2	2	3
Total	[r]32	[r]32	33
Romania:			
Pyrite[e]	[r]370	[r]370	370
Byproduct, all sources[e]	[r]84	[r]89	93
Total[e]	[r]454	[r]459	463
Saudi Arabia: Byproduct, petroleum and natural gas	[r]3	[r]3	3
Singapore: Byproduct, petroleum	6	6	7
South Africa, Republic of:			
Pyrite	225	256	333
Byproduct:			
Metallurgy	[r]69	79	90
Petroleum	[r]28	25	27
Total	[r]322	360	450
South-West Africa, Territory of: Pyrite	4	4	[e]4
Spain:			
Pyrite	1,287	1,244	1,053
Byproduct:			
Metallurgy	103	102	121
Petroleum[e]	2	2	4
Lignite gasification[e]	1	1	1
Total	[r]1,393	1,349	1,179
Sweden:			
Pyrite	215	208	203
Byproduct:			
Metallurgy	130	[e]123	[e]128
Other[25]	9	13	[e]13
Total	[r]354	[e]344	[e]344

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source —Continued

(Thousand long tons)

Country[1] and source[2]	1974	1975	1976[p]
Switzerland: Byproduct, all sources	2	2	--
Syria: Byproduct, petroleum and natural gas	(3)	1	5
Taiwan:			
Native	r4	5	6
Pyrite	4	5	3
Byproduct, all sources[e]	2	2	2
Total[e]	r10	12	11
Thailand: Byproduct, all sources[e]	1	1	1
Trinidad and Tobago: Byproduct, petroleum[4]	r29	48	54
Turkey:			
Native	r19	19	21
Pyrite	35	11	39
Byproduct, all sources	44	60	68
Total	r98	90	128
U.S.S.R.:			
Native[e]	2,360	2,460	2,460
Pyrite[e]	3,540	3,640	3,740
Byproduct, all sources[e]	1,870	1,970	2,070
Total[e]	7,770	8,070	8,270
United Kingdom:			
Byproduct:			
Metallurgy	58	r e48	e49
Spent oxides	4	--	--
Unspecified	64	72	76
Gypsum	72	e60	e10
Total	198	e180	e135
United States:			
Frasch	7,901	7,211	6,264
Pyrite	162	237	286
Byproduct:			
Metallurgy	654	767	942
Natural gas	1,211	1,342	1,277
Petroleum	1,421	1,627	1,860
Other	70	75	77
Total	11,419	11,259	10,706
Uruguay: Byproduct, petroleum	(13)	2	2
Venezuela: Byproduct, petroleum and natural gas	r107	81	89
Yugoslavia:			
Pyrite	105	165	182
Byproduct:			
Metallurgy	r172	177	187
Petroleum	4	5	5
Total	r281	347	374
Zaire: Byproduct, metallurgy	54	49	51
Zambia:			
Pyrite	29	7	9
Byproduct, all sources	44	79	90
Total	r73	86	99
Grand total	r50,345	49,877	49,741
Of which:			
Frasch	r14,323	14,096	13,157
Native	r3,165	3,225	3,334
Pyrite	r10,220	9,950	9,905
Byproduct:			
Coal gasification	1	1	1
Metallurgy	r4,715	4,612	5,017
Natural gas	r10,282	9,956	9,544
Petroleum	r2,822	3,160	3,660
Tar sands	95	84	98

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source —Continued

(Thousand long tons)

Country[1] and source[2]	1974	1975	1976[p]
Byproduct: —Continued			
Petroleum and natural gas, undifferentiated	[r]900	846	767
Spent oxides	[r]5	--	--
Unspecified sources	[r]3,667	3,805	4,171
Gypsum	[r]150	142	87

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, a number of nations may produce limited quantities of sulfur, either in the elemental state or as a compound (chiefly H_2S or SO_2), as a byproduct of petroleum and natural gas operations, and/or metallurgical operations, but output, if any, is not quantitatively reported, and no basis is available for the formulation of reliable estimates of output levels. Countries not listed in the body of the table which may have byproduct sulfur recovery from oil refining include: Albania, Bangladesh, Brunei, Burma, Costa Rica, Guatemala, Honduras, Jamaica, Malaysia, Nicaragua, Paraguay, People's Democratic Republic of Yemen, and Sri Lanka. Albania and Burma may also produce byproduct sulfur from crude oil and natural gas extractions. No complete listing of other nations which may produce byproduct sulfur in any form from metallurgical operations (including processing of coal for metallurgical use) can be compiled, but the total of such output is considered as small. Nations listed in the table which may have production from sources other than those listed are identified by individual footnotes.

[2]The term "source" reflects both the means of collecting sulfur and the type of raw material. Sources listed include the following: 1) Frasch recovery; 2) native, comprising all production of elemental sulfur by traditional mining methods (thereby excluding Frasch process recovery); 3) pyrite (whether or not the sulfur is recovered in the elemental form or as acid); 4) byproduct recovery, either as elemental sulfur or as sulfur compounds (chiefly H_2S and H_2SO_4) from a) coal gasification, b) metallurgical operations including associated coal processing, c) crude oil extraction, d) natural gas extraction, e) petroleum refining, f) tar sand cleaning, g) processing of spent oxide from stack-gas scrubbers; and 5) recovery from the processing of mined gypsum. Recovery of sulfur in the form of sulfuric acid from artificial gypsum produced as a byproduct of phosphatic fertilizer production is excluded because to include it would result in double counting. It should be noted that production of Frasch sulfur, other native sulfur, pyrite derived sulfur, mined gypsum derived sulfur, byproduct sulfur from extraction of crude oil and natural gas, and recovery from tar sands are all credited to the country of origin of the extracted raw material; in contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides are credited to the nation where the recovery takes place, which in some instances is not the original source country of the crude product from which the sulfur is extracted.

[3]Revised to zero.

[4]In addition may produce limited quantities of byproduct sulfur from natural gas.

[5]Excluding sulfur content of auriferous pyrites, for which data are not available.

[6]Excluding sulfur recovered, if any, from processing copper concentrates.

[7]Includes the following quantities recovered in elemental form in thousand long tons: 1974—26; 1975—24; 1976—59.

[8]In addition, may produce limited quantities of byproduct sulfur from crude oil and natural gas and/or from petroleum refining.

[9]Exports; regarded as tantamount to production owing to minimal domestic consumption levels.

[10]In addition, may produce limited quantities of byproduct sulfur from metallurgical operations and/or coal processing.

[11]Data represent only the sulfur content of pyrite and pyrite sands produced, and for 1975 excludes relatively small quantities of sulfur content of pyrite sands produced by Kampia Mines Ltd. from copper-zinc-iron sulfide ore; additional substantial quantities of sulfur are contained in copper concentrates exported for processing to metal , but are not reported under Cyprus because recovery of sulfur from such ores is presumably included among byproduct metallurgical recovery in the nations processing such concentrates.

[12]In addition, may produce limited quantities of byproduct sulfur from oil refining.

[13]Less than 1/2 unit.

[14]Data appearing under this heading in previous editions of this table are not native sulfur, but rather are elemental byproduct sulfur derived from metallurgical operations and as such have been included with byproduct metallurgical output.

[15]Elemental byproduct recovered sulfur only; sulfur recovered as SO_2, H_2S and/or other compounds are included under unspecified.

[16]Comprises all byproduct sulfur recovered in the form of compounds including that, if any, recovered from petroleum and natural gas operations, as well as total recovery from metallurgical operations.

[17]Official East German sources record the production of elemental sulfur as follows in thousand long tons: 1974—88; 1975—84; 1976—78. Presumably the differences between these figures and quantities listed in the body of the table represent recovery in the form of compounds.

[18]Includes only the elemental sulfur equivalent of sulfuric acid produced as a byproduct from metallurgical furnaces; additional output may be included under undifferentiated.

[19]Figure represents pyrite concentrate production; may exclude small quantities of direct-shipping grade pyrite ores.

[20]Includes recovery from gypsum, if any.

[21]Presumably includes sulfur recovered from coals processed to coke at metallurgical facilities, and excludes sulfur, if any, recovered by metallurgical facilities in elemental form.

[22]Includes sulfur recovered in the form of acid from coal, heavy oil and other unspecified sources, as well as sulfur, if any, recovered by metallurgical facilities in elemental form.

[23]Official Polish sources report the nation's total mined elemental sulfur output annually; this figure has been divided between Frasch and other native sulfur on the basis of information obtained from supplementary sources. Therefore, although both of these number are estimates, their total is not an estimate. Estimates for production of byproduct and gypsum-derived sulfur are based on officially published data on sulfuric acid production and additional information from unofficial sources.

[24]Estimates reported under the heading "Metallurgy" represent byproduct recovery in the form of compounds (principally sulfuric acid) from all sources (including coal and fertilizer plants); estimates reported under the heading "Petroleum" represent only elemental sulfur recovery from petroleum, with any recovery in the form of compounds included under the heading "Metallurgy."

[25]Elemental sulfur only.

Table 20.—World production of pyrites, by country

(Gross weight, thousand long tons)

Country[1]	1974	1975	1976[p]
North America:			
Canada	[r]48	21	30
Cuba[e]	50	50	50
United States[2]	424	625	750
Europe:			
Bulgaria[e]	[r]240	[r]240	252
Czechoslovakia	291	147	[e]187
Finland	710	707	663
Germany, East[e]	140	140	140
Germany, West	470	485	482
Greece	[r]229	[3]162	[e 3]234
Hungary[e]	7	7	7
Ireland	56	69	64
Italy	1,150	946	837
Norway	[r]648	468	362
Portugal	503	455	410
Romania[e]	[r]860	[r]860	860
Spain	2,782	2,692	2,312
Sweden	418	407	398
U. S. S. R.[e]	7,600	7,800	8,000
Yugoslavia	251	393	433
Africa:			
Algeria	(4)	--	--
Morocco	501	201	75
Rhodesia, Southern[e]	74	74	74
South Africa, Republic of	562	640	832
South-West Africa, Territory of	9	9	9
Zambia	70	19	[e]23
Asia:			
China, People's Republic of[e]	2,000	2,000	2,000
Cyprus	[r]175	[5]202	195
India	35	50	51
Japan	[r]1,265	1,079	943
Korea, North[e]	[r]600	640	690
Korea, Republic of	2	2	2
Philippines	162	159	228
Taiwan	[r]11	14	9
Turkey	75	23	83
Oceania: Australia[6]	221	221	213
Total	[r]22,639	22,007	21,898

[e]Estimate. [p]Preliminary. [r]Revised.
[1]In addition to the countries listed, Chile produces a small quantity of byproduct pyrite, but insufficient data exists for the formulation of reliable estimates of gross production.
[2]Sold or used by producers.
[3]May exclude small quantities of direct-shipping grade pyrite ore.
[4]Revised to zero.
[5]Excludes relatively small quantity of pyrite sands produced by Kampia Mines, Ltd., from copper-zinc-iron sulfide ore.
[6]Excludes production of auriferous pyrites, which is not available.

TECHNOLOGY

Polish sulfur deposits have been geologically classified as evaporite deposits, resulting from the concentration and deposition of marine salts by evaporation in shallow bays. Most geologists consider the sulfur to have been formed epigenetically, by alteration of sulfate rocks in the presence of bitumen.[8]

Laboratory tests were made on borehole samples from the Mishraq sulfur deposit to determine the effects on sulfur extraction by different hydraulic parameters and to determine a technique to estimate sulfur recovery.[9]

A number of processes are being tried to pelletize sulfur for shipment to avoid dust loss, and reduce risk of fire or explosions. One process involving water quenching to produce spherical pellets is being pilot tested in Canada. A process to form sulfur prills by air quenching has been developed in Poland.[10]

[8]Slizowski, Kayimiez. The Polish Sulphur Industry. Sulphur (London), No. 122, January-February 1976, pp. 20-26.

[9]Featherstone, R. E., and A. M. AlSamarrie. Mishraq Sulphur Deposit, Hydrodynamic Effects of Sulphur Extraction: Sulphur Recovery Prediction. Sulphur (London), No. 124, May-June 1976, pp. 20-24.

[10]Leszczynska, Halina. Sulphur Forming-the Polish Experience. Sulphur (London), No. 123, March-April 1976, pp. 44-46.

Work under a cost sharing agreement with the Bureau of Mines was initiated by St. Joe Minerals Corp. to demonstrate the citrate process SO_2 removal system at a coal burning powerplant. A study was made to evaluate the potential marketing of abatement acid and sulfur from fossil-fuel-fired powerplant sources.[11]

A method was demonstrated to recover sulfur from stack gases by scrubbing with ammonia liquor followed by conversion to elemental sulfur and ammonia for recycling.[12]

Sulfur dioxide emissions at Japanese copper smelters is recovered as readily marketable products such as sulfuric acid, gypsum, and sodium salts.[13]

Several processes for removal of sulfur oxides from waste gases were selected for review and evaluation of status.[14]

The substitution of sulfur for asphalt in road paving has been tested in several countries. Test sections constructed in roads and highways have indicated use of up to 13% sulfur in asphaltic paving provides an acceptable surface.[15]

Sulfur was added to improve compression, flexural, and tensile strength of concretes.[16]

A sulfur coating material was applied to a variety of surfaces such as concrete, earth, and wood. Tests indicate improved resistance to corrosion and damage due to winter temperatures.[17]

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[11]Bucy, J. I., J. L. Nevins, P. A. Corrigan, and A. G. Melicks. Potential Utilization of Controlled SO_x Emissions from Power Plants in Eastern United States. Pres. at Sixth Flue Gas Desulfurization Symposium, New Orleans, La. Mar. 8-11, 1976, 52 pp.

[12]Engineering and Mining Journal. SO_2 Cleanup: IFP Joins the System Chase. V. 177, No. 12, December 1976, p. 69.

[13]Rosenbaum, J. B., Masami Hayashi, and G. M. Potter. Sulfur Dioxide Emission Controls in Japanese Copper Smelters. BuMines IC 8701, 1976, 15 pp.

[14]Stack, A. V. Flue Gas Desulfurization: An Overview. Chem. Eng. Process., v. 72, No. 8, 1976, pp 94-97.

[15]Sulphur (London). SVDIC: A Canadian Response to the Sulfur Challenge. No. 122, January-February 1976, pp. 45-50.

Chemical Week. Paving the Way to New Markets. V. 119, No. 6, Aug. 11, 1976, p. 20.

Engineering News Record. Cost-Cutting Sulfur Pavements Making Inroads. V. 197, No. 14, September 30, 1976, pp. 18-19.

[16]Sullivan, T. A., and W. C. McBee. Development and Testing of Superior Sulfur Concretes. BuMines RI 8160, 1976, 30 pp.

[17]Canadian Mining Journal. SuCoat Test at Cominco. V. 97, No. 10, 1976, p. 73.

Sulphur (London). Sulphur Coatings. No. 126, September-October 1976, pp. 44-45.

Talc and Pyrophyllite

by Robert A. Clifton[1]

The partial recovery from the economic recession of 1975 gave rise to a 13% increase in total domestic production of talc and pyrophyllite. Domestic production of both talc and pyrophyllite increased: world production of both was up 10%. Soapstone data is included with that of talc.

The apparent 90% increase in value of the talc minerals sold is due more to statistical technique changes than to market changes. Apparent consumption decreased 11%.

The Johns-Manville Corp. closed both its Los Angeles mill and its Warm Springs, Calif., mine. This corporation also announced the start of production at a talc mine near Timmins, Ontario, Canada.

Cyprus Industrial Minerals Co. restructured its operations into two separate divisions, talc and clay, and named an executive vice-president to head each. Tredmont, Inc., purchased the Boren and Harvey pyrophyl-

[1]Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient talc and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Mine production:					
Talc	W	W	1,183	873	W
Pyrophyllite	W	W	106	92	W
Total	1,107	1,247	1,289	[r]965	1,092
Value:					
Talc	W	W	$8,022	$7,454	$9,542
Pyrophyllite	W	W	1,547	1,475	360
Total	$7,835	$9,144	9,569	[r]8,929	9,902
Sold by producers:					
Talc	994	1,071	963	845	794
Pyrophyllite	90	113	101	86	107
Total	1,084	1,184	1,064	[r]931	901
Value:					
Talc	$32,473	$30,757	$31,125	$16,496	$33,014
Pyrophyllite	1,236	1,469	1,474	1,379	934
Total	33,709	32,226	32,599	[r]17,875	33,948
Exports[1]	171	180	183	158	212
Value	$5,791	$6,618	$6,711	$6,338	$9,034
Imports for consumption	29	23	30	23	20
Value	$1,669	$1,658	$2,233	$1,471	$1,861
Apparent consumption	942	1,027	911	796	709
World: Production	5,324	5,957	[r]6,406	[r]5,385	5,944

[r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]Excludes powders—talcum (in package), face, and compact.

lite properties in North Carolina late in 1976.

Legislation and Government Programs.—Congress enacted Public Law 94-420 effective in September 1976, which closed Death Valley National Monument, among others, to mineral entry and location, imposed a 4-year moratorium on mineral exploration and development, and restricted surface disturbance to those areas where minerals had been extracted prior to February 29, 1976. Continued extraction was limited to the average annual rate of 1973, 1974, and 1975.

The General Services Administration reported that the national stockpile inventory of talc consisted of 1,119 short tons of steatite, block or lump, and 2,916 short tons of ground steatite. This represented a 30-ton drop in the block inventory and a static powder inventory. The block steatite was sold for $290 per ton.

The Office of Minerals Exploration, Geological Survey, offered to grant loans of up to 50% of approved exploration costs for eligible deposits of block steatite talc, but no loans for that purpose were made in 1976. The allowable depletion rates for talc, established by the Tax Reform Act of 1969 and unchanged through 1976, were 22% on production of block steatite talc of domestic origin and 14% on foreign production of the same material, which rate applied also to production of all other classes of talc from all sources.

DOMESTIC PRODUCTION

Talc.—Production from United States talc mines in 1976 was up over that of 1975 but still below that of the record high established in 1974. The value of the mine production, however, established a new record dollar high, 19% over the 1974 high.

Talc (including soapstone) was produced at 36 mines in 12 States in 1976, with California having by far the largest number of active mines at 10. Mines in four States produced 90% of the tonnage and 75% of the value of talc in 1976, and the production in eight other States accounted for the rest. The highest producing States in decreasing order are Vermont, Montana, New York, and Texas. Montana led all the States in the value of the talc produced. Every State, with the exception of Nevada, that mined talc had one or more mills to process the ore.

The seven largest domestic producers of talc in 1976, listed alphabetically, were Cyprus Industrial Minerals Co., with mines in California, Montana, and Texas; Eastern Magnesia Talc Co. in Vermont; Pfizer Inc., Minerals, Pigments & Metals Div., in California and Montana; Southern Clay Products, Inc., in Texas; R. T. Vanderbilt Co., Inc., in New York; and Windsor Minerals, Inc., in Vermont. Those firms supplied 96% of the 1976 tonnage, and the combined output of about 15 smaller producers made up the remainder.

Pyrophyllite.—Pyrophyllite is a natural hydrous aluminum silicate whose empirical chemical formula is $Al_2Si_4O_{10}(OH)_2$. Because of some properties similar to talc, some shared markets, and a degree of substitutability, it has long been associated with this mineral and some of the data concerning both is obscured by the combination of the two. The end uses of the twominerals are showing some divergence because of their differing chemistry and high temperature characteristics.

Pyrophyllite production in 1976 was above that of 1975 and established a new record high year. The lack of production at the Interpace Corp.'s mine in California left North Carolina as the only State producing pyrophyllite in 1976. Four companies operated six mines during the year.

Table 2.—Talc and pyrophyllite produced in the United States, by State

(Short tons and thousand dollars)

State	1975 Quantity	1975 Value	1976 Quantity	1976 Value
California (talc)	152,978	1,598	56,871	1,513
Georgia (talc)	27,400	82	W	W
Montana (talc)	W	W	224,753	2,960
North Carolina[1]	95,575	r1,605	113,754	1,087
Texas (talc)	129,626	795	199,663	1,071
Vermont (talc)	230,973	1,918	252,371	1,685
Other States[2] (talc)	328,057	2,931	245,021	1,586
Total	r964,609	r8,929	1,092,433	9,902

rRevised. W Withheld to avoid disclosing individual company confidential data.
[1]Talc and pyrophyllite produced.
[2]Includes Alabama (1975), Arkansas, Georgia (1976), Montana (1975), Nevada, New York, Oregon, Virginia, and Washington.

CONSUMPTION AND USES

The apparent domestic consumption of talc and pyrophyllite in 1976 decreased 11% from that in 1975 and was just 69% of the 1973 record high. The $34 million sales value was a new record high.

The 1976 end-use distribution showed 33% of the ground talc used in ceramics, 24% in paint, about 8% each in paper and plastics, 7% in roofing, more than 5% in cosmetics, 3% in insecticides, 2% in rubber, 1% in refractories, and the remainder in other uses.

The largest portion (50%) of pyrophyllite was used in refractories, 20% in ceramics, 16% in insecticides, and 14% in other uses.

Table 3.—End uses for ground talc and pyrophyllite, 1976

(Short tons)

Use	Talc	Pyrophyllite	Total
Ceramics	258,840	21,473	280,313
Cosmetics[1]	36,788	50	36,838
Insecticides	23,268	17,100	40,368
Paint	188,952	2,149	191,101
Paper	60,212	--	60,212
Plastics	59,767	--	59,767
Refractories	8,717	53,334	62,051
Roofing	52,471	629	53,100
Rubber	18,443	239	18,682
Other uses[2]	86,298	12,326	98,624
Total	793,756	107,300	901,056

[1]Incomplete data. Some cosmetic talc known to be included in "Other."
[2]Includes art sculpture, asphalt filler, crayons, floor tile, foundry facings, rice polishing, stucco, and other uses not specified.

PRICES

Engineering and Mining Journal, December 1976, quoted prices for domestic talc, ground, in carload lots, f.o.b. mine or mill, containers included, per short ton, as follows:

Vermont:	
98% through 325 mesh, bulk	$38.00-$47.00
99.99% through 325 mesh, bags:	
Dry processed	75.00- 84.00
Water beneficiated	122.00-140.00
New York:	
96% through 200 mesh	36.00- 38.00
98 to 99.25% through 325 mesh	48.00
100% through 325 mesh, fluid energy ground	75.00-105.00
California:	
Standard	69.50
Fractionated	37.00- 71.00
Micronized	62.00-104.00
Cosmetic steatite	44.00- 65.00
Georgia:	
98% through 200 mesh	20.00
99% through 325 mesh	35.00
100% through 325 mesh, fluid energy ground	85.00

American Paint and Coatings Journal, January 3, 1977, listed the following prices per ton for paint-grade talcs in carload lots:

California:	
325 mesh, bags, mill:	
Fibrous, white, high oil absorption	$34.00-$37.00
Semifibrous, medium oil absorption	32.00- 73.95
Montana: Ultrafine grind, f.o.b. mill	70.00
New York:	
Nonfibrous, bags, mill:	
98% through 325 mesh	46.50- 50.50
99.4% through 325 mesh	55.50
Trace retained on 325 mesh	105.00
Fine micron talcs (origin not specified)	68.00-111.50

The approximate equivalents, in dollars per short ton, of the price ranges quoted in Industrial Minerals (London), December 1976, for steatite talc, c.i.f., main European port, were as follows:

Norwegian:	
Ground (ex store)	$45.00-$47.00
Micronized (ex store)	72.00-106.00
French, fine ground	61.00-136.00
Italian, cosmetic grade	136.00-167.00
Chinese	106.00-122.00

FOREIGN TRADE

Exports.—The quantity of talc exported from the United States during 1976 exceeded that of 1975 by 34% and that of the previous record high year (1974) by 16%. The value of the exports exceeded that of 1975 by 43% and that of the previous record high year (1974) by 35%.

Mexico was the destination of 55% of the exports at an average value of $18.21 per ton. Canada's 19% of the exports averaged $64.78 per ton; Belgium's 10%, $52.12 per ton; Japan's 6%, $54.70 per ton; and Venezuela's 3%, $128.92 per ton. The remaining 7% went to 51 countries. The average value of all exports was $42.54 per ton.

Imports.—The quantity of talc imported for consumption continued to decline from the 1974 high. The 1976 imports were 87% of those in 1975 and 67% of those in 1974. The value of the 1976 imports, however, rose 27% over that of 1975.

Table 4.—U.S. exports of talc, crude and ground

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1974	183	6,711
1975	158	6,338
1976	212	9,034

Table 5.—U.S. imports for consumption of talc, by class and country

Year and country	Crude and unground		Ground, washed, powdered, or pulverized		Cut and sawed		Total unmanufactured	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value[1] (thousands)
1974	21,592	$1,095	7,857	$541	803	$597	30,252	$2,233
1975:								
Australia	--	--	--	--	(2)	(2)	(2)	(2)
Canada	3,447	76	3,233	174	5	2	6,685	252
France	4,432	110	4,802	170	--	--	9,234	280
Germany, West	--	--	--	--	(2)	1	(2)	1
Hong Kong	--	--	--	--	29	19	29	19
Iceland	--	--	20	2	--	--	20	2
Israel	--	--	34	8	--	--	34	8
Italy	6,063	476	356	72	--	--	6,419	548
Japan	--	--	--	--	271	213	271	213
Korea, Republic of	--	--	559	68	127	79	686	147
United Kingdom	(2)	1	--	--	--	--	(2)	1
Total	13,942	663	9,004	494	432	314	23,378	1,471
1976:								
Australia	--	--	1	1	--	--	1	1
Belgium-Luxembourg	--	--	17	6	--	--	17	6
Canada	3,840	92	2,873	162	6	3	6,719	257
Finland	--	--	4	(2)	--	--	4	(2)
France	--	--	592	54	--	--	592	54
Hong Kong	--	--	--	--	218	119	218	119
India	--	--	22	2	3	1	25	3
Israel	--	--	137	9	--	--	137	9
Italy	10,913	926	287	57	--	--	11,200	983
Japan	--	--	67	8	246	208	313	216
Kenya	(2)	1	--	--	--	--	(2)	1
Korea, Republic of	55	3	505	54	244	150	804	207
Netherlands	--	--	2	1	--	--	2	1
Spain	6	1	--	--	--	--	6	1
United Kingdom	--	--	33	3	--	--	33	3
Total	14,814	1,023	4,540	357	717	481	20,071	1,861

[1]Does not include talc, n.s.p.f.; 1974-$224,375; 1975-$198,090; 1976-$302,455.
[2]Less than 1/2 unit.

WORLD REVIEW

Australia.—Roughly half of Australia's talc production comes from the open pit mine of Three Springs Talc, Pty. Ltd., near the town of Three Springs about 211 miles north of Perth. Drilling and blasting give a product that has a ratio of waste and substandard talc to the first grade talc of about 4.5:1. The company has a 220-short-ton-per-day treatment plant.

Canada.—Canadian Johns-Manville Corp. brought onstream Canada's fourth talc mining operation in July. The mine is located in Penhorwood Township, 45 miles southwest of Timmins in Northern Ontario. It will have an estimated capacity of 20,000 to 30,000 tons per year and the ore will be flotation concentrated at mine-site. Drying and milling will occur at a facility in Timmins.

China, People's Republic of.—China's exports of talc nearly tripled in the 10-year period 1965-74 from 91,000 to 259,000 short tons. The value of these exports more than quadrupled in those years from $2.4 to $11.1 million.

Finland.—A talc-magnesite deposit at Polvijarvi, 15 miles from Outokumpu in Eastern Finland, will be exploited in a joint venture by Oy Lohja A. B. and Outokumpu Oy. The ore, 60% talc, 40% magnesite, and 0.18% nickel, will be processed by flotation for separation of the talc and nickel constituents. The talc plant, scheduled for August 1977 startup, will be near the town of Joensuu. Initial capacity is planned to be 150,000 tons per year of micronized talc of 90% brightness for the Scandinavian paper industry.

India.—The Indian Bureau of Mines reported that of the 15 million tons of talc reserves in the country, 55% are in Maharashtra and 42% in Rajasthan. The paper

Table 6.—Talc, soapstone, and pyrophyllite: World production by country

(Short tons)

Country[1]	1974	1975	1976[p]
North America:			
Canada (shipments)	94,746	72,784	71,000
Mexico	2,920	1,631	212
United States	1,289,502	964,969	1,092,433
South America:			
Argentina	44,721	38,581	[e]38,600
Brazil (talc and pyrophyllite)	221,767	243,248	[e]250,000
Chile	1,856	524	149
Colombia	882	1,102	[e]1,100
Paraguay	276	[e]280	154
Peru (talc and pyrophyllite)	15,191	[r][e]15,400	[e]15,400
Uruguay	2,287	1,398	1,398
Europe:			
Austria	108,511	95,363	116,458
Finland	141,392	136,973	163,727
France (ground talc)	328,852	265,800	279,634
Germany, West (marketable)	31,429	[e]33,000	[e]33,000
Greece (steatite)	4,762	6,460	[e]6,600
Hungary[e]	17,600	17,600	17,600
Italy (talc and steatite)	170,819	158,823	169,575
Norway	124,590	115,735	[e]110,000
Portugal	1,091	1,731	1,263
Romania[e]	66,000	66,000	66,000
Spain	[r]60,614	52,159	[e]55,000
Sweden	31,310	26,286	22,046
U.S.S.R.[e]	450,000	460,000	485,000
United Kingdom	[r]22,708	21,054	[e]22,000
Africa:			
Angola[e]	110	110	110
Egypt	4,345	3,055	6,213
Ethiopia	3	28	[e]30
South Africa, Republic of[2]	19,951	17,657	14,135
Sudan	5,512	[e]5,500	[e]5,500
Swaziland (pyrophyllite)	40	--	--
Zambia	152	181	117
Asia:			
Afghanistan[3]	3,307	6,945	9,574
Burma	464	383	462
China, People's Republic of[e]	[r]330,000	300,000	330,000
India	[r]340,131	220,981	266,459
Japan[4]	1,734,878	1,313,489	1,482,875
Korea, North[e]	130,000	140,000	140,000
Korea, Republic of (talc and pyrophyllite)	487,322	458,422	547,262
Nepal[5]	278	571	57
Pakistan (talc and soapstone)	7,776	3,921	4,807
Philippines	2,572	1,479	[e]1,650
Taiwan	14,900	13,283	17,065
Thailand (talc and pyrophyllite)	1,982	11,736	[e]11,000
Oceania: Australia	[r]88,005	90,816	[e]88,000
Total	[r]6,405,554	5,385,458	5,943,665

[e]Estimate. [p]Preliminary. [r]Revised.
[1]In addition to the countries listed, Southern Rhodesia is believed to produce talc, but available information is inadequate to make reliable estimates of output levels.
[2]Includes talc and wonderstone (pyrophyllite).
[3]Data are for calendar year beginning March 20 of that stated.
[4]Includes talc and pyrophyllite; in addition, pyrophyllite clay is produced as follows in short tons: 1974—466,030; 1975—483,857; 1976—Not available.
[5]Data based on Nepalese fiscal year, beginning mid-July of year stated.

industry uses 53% of the domestic consumption; insecticides and pesticides, 30%; cosmetics, 5%; and ceramics, 3%.

Japan.—The Japanese refractories industry consumed 380,000 short tons of pyrophyllite (including some diaspore) in 1965 and had increases practically every year until it reached 771,000 short tons in 1973, the peak year. The next 2 years saw a decline in consumption with just 558,000 short tons used in 1975.

Japanese imports of talc were 329,603 short tons in 1974 and 260,359 short tons in 1975. The People's Republic of China was by far the biggest supplier with 53% of the 2-year total.

Spain.—Spanish apparent consumption of talc grew dramatically in 1974. Domestic production, a nominal 40,000 tons per year, rose to 61,000 tons that year and imports doubled from 5,000 to 10,000 tons. Talc is produced near Bonar in Leon Province, around Figueras in Gerona Province, and near Fuengirola in Malaga Province.

Turkey.—Reported mineral reserves found in Eskisehir Province of Turkey include 400,000 tons of talc.

• TECHNOLOGY

The existence at Pambula in Southeastern Australia of a pyrophyllite deposit with an inferred 30 million short tons of ore belonging to Pyrophyllite Corp. Ltd., has prompted the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) to initiate market development research. The CSIRO reported that experimental pyrophyllite bricks lining steel production ladles have doubled the pour life for such bricks. Pyrophyllite and zircon bricks tripled the pour life. CSIRO scientists say that the addition of pyrophyllite to road surfacing materials not only toughens the surface and extends the useful life of the materials, but imparts a soft glow to the surface, making night driving safer.

Alfred University's Research Foundation was the recipient of a grant from Windsor Minerals, Inc. The research covered by the grant is aimed at reclamation and utilization of talc mining waste residues.

The Cosmetic, Toiletry and Fragrance Association announced an industry-wide review of cosmetic product ingredients. The multi-year project will gather health effects data for presentation to the Food and Drug Administration.

An international trade magazine[2] reported that talc filler is upgrading the properties of engineering plastics in several areas. Talc-filled polypropylene in new "esthetic" grades that overcome the former limitations of whitening and dull appearance are now available. They retain the desirable properties of higher stiffness and better resistance to warping and sink marks that characterized the older talc-filled polypropylene.

Cyprus Mines Corp. patented its process for separating molybdenum and talc. In this process the talc is depressed and higher concentrations of molybdenum recovered. A high energy using oxidizing roast of the ore was eliminated using the new process.

The Joseph Dixon Crucible Co. is now producing processed soapstone for use by welders. The pressed talc soapstone, formed in either flat, round or square crayons, is uniform without the hard spots or flaws of the natural product and is less brittle.

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[2]Modern Plastics International. V. 13, No. 10, October 1976, pp. 13-14.

Thorium

By Martha L. Kahn[1]

Thorium was an unused coproduct of mine production during 1976, and demand for thorium was not the decisive factor in determining its supply. Monazite, the principal source of thorium, continued to be a byproduct of titanium and tin mining and was recovered for its rare-earth content. Byproduct monazite was recovered in Florida by Humphreys Mining Co. and Titanium Enterprises. Thorium-containing residues remaining after extraction of rare earths from monazite were stored for future use. Practically all thorium compounds used by the domestic industry during 1976 came from previous company stocks or imports.

Several occurrences of thorium of potential economic significance were described in 1976. These included new occurrences in Alaska and South Dakota, as well as deposits in Colorado and Tennessee that were under study by mining companies to determine economic feasibility.

No major developments occurred in the nonenergy uses of thorium, which included mantles for incandescent lamps, hardeners in magnesium alloys, refractories, and electronic and chemical applications.

The future prospects for thorium's use in nuclear fuels remained uncertain in 1976. The only commercial thorium-fueled, high-temperature, gas-cooled reactor (HTGR), located at Fort St. Vrain, Colo., with a capacity of 330 megawatts (MW), began commercial operation in December 1976 and was expected to reach full power in late 1977.

DOMESTIC PRODUCTION

Exploration.—Significant concentrations of thorium, associated with uranium and rare-earth elements, were discovered on Seward Peninsula in western Alaska.[2] Samples of the mineralized rock, which occurs along alkaline dikes in a 100-square-mile area, contained as much as 1.05% thorite. Uranium- and thorium-bearing parts of the Precambrian Estes Conglomerate were found in Lawrence County, S. Dak.[3] Samples from deeply weathered surface exposures contained as much as 800 parts per million thorium. Thorium occurrences in the Upper Peninsula of Michigan and northern Wisconsin were described.[4]

A report on thorium resources of the United States in 1974 was made available to the public in 1976.[5] The report indicated that thorium reserves are in beach placers, and most identified resources are in veins, carbonatites, and stream placers.

Buttes Gas and Oil Co. continued feasibility and pilot-plant studies of its southwestern Colorado titanium prospect.[6] The ore mineral perovskite reportedly contains significant amounts of thorium that could be recovered. Kerr-McGee Chemical Corp. reported 74,000 short tons of indicated recoverable monazite contained in its heavy-mineral sands deposit in Benton County, Tenn.

Mine Production.—Monazite, a thorium-containing rare-earth phosphate mineral,

[1]Physical scientist, Division of Nonferrous Metals.

[2]Miller, T. P., R. L. Elliott, W. I. Finch, and R. A. Brooks. Preliminary Report on Uranium, Thorium and Rare-Earth-Bearing Rocks near Golovin, Alaska. U.S. Geol. Survey Open File Rept. 76-710, 1976, 13 pp.

[3]Skillings' Mining Review. Uranium-Thorium-Bearing Rocks in South Dakota. V. 66, No. 9, 1977, p. 15.

[4]Kalliokoski, J. Uranium and Thorium Occurrences in Precambrian Rocks, Upper Peninsula of Michigan and Northern Wisconsin, With Thoughts on Other Possible Settings. Michigan Technological University, Houghton, Mich. Dept. of Geol. and Geological Eng., 1976, 350 pp.

[5]Staatz, M. H. Thorium Resources 1974. U.S. Geol. Survey Open File Rept. 78-690, 1976, 5 pp.

[6]E/MJ International Directory Mining Activity Digest. New Development Highlights. V. 2, No. 10, 1976, p. 1.

was produced as a byproduct of processing beach sands for titanium minerals in 1976. Two mines in Florida, Humphreys Mining Co., near Hilliard, and Titanium Enterprises, near Green Cove Springs, were the only domestic producers of monazite. Humphreys Mining Co. continued to truck wet titanium concentrates from its mine in Florida to the company's dry plant at Folkston, Ga. U.S. mine production of thorium in 1976 was less than the 1975 production.

Refinery Production.—In 1976 there was only one domestic firm, W. R. Grace & Co., Davison Chemical Division, at Chattanooga, Tenn., with facilities for processing large tonnages of monazite. Although Grace did not produce any thorium compounds from monazite for sale, thorium was extracted from monazite during the refining of rare-earth elements and stored. Practically all thorium compounds used by the domestic industry during 1976 came from previous company stocks or imports.

Table 1.—Companies with thorium processing and fabricating capacity

Company	Plant location	Operations and products
Atomergic Chemetals Corp	Plainview, N.Y.	Processes oxide, fluoride, and metal.
Consolidated Aluminum Corp	Madison, Ill	Magnesium-thorium alloy.
Controlled Castings Corp	Plainview, N.Y	Do.
General Atomic Co	San Diego, Calif	Nuclear fuels.
General Electric Co	San Jose, Calif	Do.
Do	Wilmington, N.C	Do.
W. R. Grace & Co	Chattanooga, Tenn	Processes domestic and imported monazite; produces oxide; stocks of hydroxide and metal powder.
Gulf United Nuclear Fuels Corp	Hematite, Mo	Nuclear fuels.
Do	New Haven, Conn	Do.
Hitchcock Industries, Inc	South Bloomington, Minn.	Magnesium-thorium alloys.
Kerr-McGee Chemical Corp	Cimarron, Okla	Nuclear fuels.
NL Industries, Inc	Albany, N.Y.	Do.
Nuclear Chemicals and Metals Corp	Huntsville, Tenn	Do.
Nuclear Fuels Services, Inc	Erwin, Tenn	Do.
Nuclear Materials&Equipment Corp. (NUMEC)	Apollo, Pa	Do.
Do	Leechburg, Pa	Do.
Ventron Corp.,Alfa Div	Danvers, Mass	Metallic thorium.
Westinghouse Electric Corp	Bloomfield, N.J	Processes compounds; produces metallic thorium.
Do	Columbia, S.C	Nuclear fuels.

CONSUMPTION AND USES

Based on domestic mine production, releases from the Government stockpile, and foreign trade, the estimated apparent domestic consumption of thorium contained in monazite and thorium compounds for 1976 was 236 short tons of ThO_2 equivalent. However, monazite was processed mainly for its rare-earth content, and the thorium residues were stockpiled. The actual industrial demand for thorium was about 45 tons of ThO_2 equivalent, based mainly on shipments from processors. This was below the 1975 consumption level of 50 tons. The decline in consumption during 1976 was mainly due to low demand in energy applications.

Nonenergy uses consumed about 35 tons of ThO_2. The principal application was as a constituent in mantles for Welsbach incandescent lamps (estimated to be around 18 tons). Other nonenergy uses were as follows: As a hardener in magnesium-thorium alloys (4 tons); in refractories (4 tons); in electronic and chemical applications, plus other applications and research (9 tons).

The 330-megawatt HTGR at Fort St. Vrain, Colo., began producing electricity on December 11, 1976, and was up to 21% of electrical capacity by the end of 1976. The core of the reactor contains about 22 tons of thorium. A reload section containing about 3 tons of thorium was scheduled to be added annually.

Development of a thorium-fueled, light-water breeder reactor (LWBR) continued at Shippingport, Pa. Initial loading of about 46 tons of thorium was expected to take place in 1977, with power production scheduled for 1978.

STOCKS

On December 31, 1976, the General Services Administration (GSA) stockpile inventory totaled 7,265,004 pounds of thorium nitrate (1,680 short tons ThO_2 equivalent). On October 1, 1976, the thorium nitrate stockpile goal was set at 1,800,000 pounds (418 short tons ThO_2 equivalent).

The Energy Research and Development Administration (ERDA) inventory as of December 31, 1976, was 1,068 short tons of thorium. About 149 tons of this material was being utilized in research and development.

Industrial stocks of thorium at the end of 1976 were less than at the end of 1975. Estimated industrial stocks at yearend in terms of ThO_2 equivalent were as follows: Monazite, 98 tons; and in compounds and metal, 355 tons.

PRICES

Prices for domestic monazite containing approximately 4% ThO_2 rose about 25% in 1976. The average declared value of imported monazite (all from Malaysia) decreased slightly to $205 per short ton from $207 in 1975. The average price per short ton of Australian monazite quoted in Metal Bulletin (London) remained constant during 1976 at A$170 to A$185. However, the price of Australian monazite in U.S. dollars fell about 17% in December 1976 owing to the devaluation of Australian currency.

Prices for thorium compounds varied depending upon purity and quantity. Thorium nitrate, mantle grade, was quoted at $3 per pound; thorium oxide, ceramic grade, $5.80 to $10 per pound; thorium metal in pellets, $15 per pound; and metal powder, $65 per pound.

FOREIGN TRADE

During 1976, no thorium concentrates or ores were exported. Other thorium export data were combined with those for uranium. Although these two elements were not statistically differentiated, it was believed that the amount of thorium exported was minor.

Monazite containing about 6% thorium was imported from Malaysia for its rare-earth content. In 1976, imports of gas mantles and thorium compounds decreased.

Table 2.—U.S. foreign trade in thorium and thorium-bearing materials

(Quantity in pounds unless otherwise specified)

	1974		1975		1976		Principal sources and destinations, 1976
	Quantity	Value	Quantity	Value	Quantity	Value	
EXPORTS							
Ore and concentrate (ThO_2 content)	156,430	$270,252	--	--	--	--	
Metals and alloys[1]	20,496	321,982	14,840	$203,415	7,018	$145,758	Italy 2,355; Japan 1,686; Canada 1,661; Yugoslavia 480; Mexico 287; Venezuela 274; Switzerland 190; Other 85.
Compounds[1]	4,682,926	30,855,227	3,837,266	52,039,852	369,036	7,232,389	United Kingdom 308,038; West Germany 43,582; Netherlands 13,659; Canada 2,104; Other 1,653.
IMPORTS							
Ore and concentrate:							
Monazite (short tons)	1,320	200,527	2,565	531,958	2,103	430,551	All from Malaysia.
ThO_2 content	158,400	XX	307,800	XX	252,360	XX	Do.
Waste and scrap	15	303	115	2,165	--	--	
Compounds:							
Nitrate	8,083	13,939	66,102	118,343	69,900	152,860	France 66,800; Canada 3,100.
Oxide	12,000	48,781	9,500	55,382	5,007	16,517	All from France.
Oxide equivalent, in gas mantles[e] [2]	3,349	399,545	2,374	361,268	1,889	355,885	Malta 939; United Kingdom 684; Austria 104.
Other	172	23,394	76	18,438	71	19,085	Switzerland 65; West Germany 6.

[e]Estimate. XX Not applicable.
[1]Includes uranium; thorium and uranium are undifferentiated in official statistics.
[2]Based on the manufacture of 1,000 gas mantles per pound ThO_2.

WORLD REVIEW

The predominate source of the world's thorium is monazite, a byproduct of titanium and tin mining. Australia, India, Malaysia, Brazil, and the United States continued to be the leading monazite producers among market-economy countries. The small world demand for thorium, however, is not reflected by the quantity of this production, since monazite is processed mainly for its rare-earth element content.

Table 3.—Monazite concentrate: World production, by country

(Short tons)

Country[1]	1974	1975	1976[p]
Australia	[r]3,943	4,968	5,016
Brazil	1,318	[r] [e]1,600	[e]1,600
India[e]	3,300	3,300	3,300
Korea, Republic of[e]	10	10	10
Malaysia[2]	1,965	3,621	2,071
Nigeria	12	[r] [e]20	[e]20
Sri Lanka	[r]6	[re]5	1
Thailand	486	405	[e]400
United States	W	W	W
Zaire	261	328	265
Total	[r]11,301	14,257	12,683

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]In addition to the countries listed, Indonesia and North Korea may produce monazite, but information is inadequate to make reliable estimates of output levels.
[2]Exports.

Australia.—According to the Rutile & Zircon Development Association, Ltd., 1976 monazite production by member companies, by state was as follows: New South Wales, 1,089 short tons; Queensland, 227 short tons, and Western Australia, 3,698 short tons.

Metals Exploration Ltd. and Alliance Oil Development Australia NL announced the discovery of mineral sands containing about 800,000 short tons of heavy minerals at Cataby, 93 miles north of Perth.[7] The heavy minerals contain about 1.5% monazite. Westralian Sands Ltd., a producer of byproduct monazite, resumed full scale mining operations at Yoganup.[8] The mine and treatment plant had been on a care and maintanence basis due to low demand for ilmenite.

Canada.—Research continued on a thorium cycle for the Canadian-deuterium-uranium (CANDU) reactor. Studies indicated that thorium could probably be burned in combination with enriched uranium or plutonium in the CANDU with minor if any changes. However, since the CANDU presently uses only unenriched uranium, an advanced fuel technology must be developed before the thorium cycle could be implemented.

Germany, West.—Construction of the 300 megawatt pebble-bed thorium high-temperature reactor (THTR) at the Hamm-Uentrop station of Vereinigte Elektrizitaetswerke Westfalen AG continued. Completion of the THTR developed by Hochtemperatur-Reaktorbau GmbH was rescheduled for mid-1978.[9]

General Atomic Co. (San Diego) has joined four German and four Swiss firms in developing a gas turbine HTGR.[10] The gas turbine powerplant would not require cooling water since waste heat would be released to the air.

India.—An estimated 500,000 tons of monazite sands found in a 16 mile belt in the coastal areas of Ganjam and Puri districts in Orissa State was reported by the Minister for Mining and Geology.[11]

[7]Mining Journal. Mineral Sands at Cataby. V. 287, No. 7353, July 23, 1976, p. 68.
[8]European Chemical News. Newsbriefs. V. 29, No. 752, Sept. 10, 1976, p. 8.
[9]Nuclear News. West Germany Taking the Initiative. V. 19, No. 8, June 1976, pp. 79-87.
[10]Chemical Week. New Nuclear Reactor Will Be Developed by U.S.-European Team. V. 119, No. 19, Nov. 10, 1976, p. 1.
[11]Engineering & Mining Journal. India: Monazite Sand. V. 177, No. 5, May 1976, p. 180.

TECHNOLOGY

A patent was issued for the extraction of columbium, rare-earths, and thorium from pyrochlore.[12] Thorium has never been commercially produced from pyrochlore, which is a major source of columbium.

A thorium-containing personnel neutron dosimeter, to be worn as a monitoring device for recording radiation exposure, was developed.[13] When a fast neutron hits the thorium target, the fission fragments given off are recorded on a detector foil that can be periodically removed for analysis. This new dosimeter was reportedly insensitive to gamma rays and X-rays and relatively insensitive to light, temperature, and humidity compared with some conventional dosimeters. The Nuclear Regulatory Commission was expected to grant a licensing exemption for personnel dosimeters containing not more than 50 milligrams of thorium.

A 2-year occupational health study to determine possible effects of thorium on the human body was begun by the Argonne National Laboratory of ERDA.[14] The study was to involve over one hundred former employees of the now-closed Lindsay Light and Chemical Co., a former thorium processor.

Research continued on the thorium fuel cycle in several different reactors, including the HTGR, LWBR, CANDU, light-water reactor, liquid-metal fast-breeder reactor, and gas-cooled fast-breeder reactor (GCFR). Large-scale development of any of these reactors could substantially increase the consumption of thorium.

General Atomic Co. (GA) developed unit processes and equipment for reprocessing HTGR fuel and designed and developed an integrated line to demonstrate the head end of HTGR reprocessing using unirradiated fuel materials. Trade-off studies were also made concerning the required design of facilities for large-scale recycling of HTGR fuels, in order to guide the development activities for recycling HTGR fuel.[15] ERDA and GA also studied the gas turbine HTGR and the HTGR steam cycle. The gas turbine HTGR was of particular interest since it would require no cooling water, could be used in arid regions, and would still reach thermal efficiencies of over 40% under these conditions.

Research on the use of thorium-fuel in a GCFR nuclear power system were still underway by ERDA. The GCFR utilizes the coolant and nonnuclear component technology of the conventional HTGR. GA expected the GCFR, under steady-state conditions, would produce enough fuel for four thermal reactors.

ERDA was expected to load the Shippingport LWBR with thorium-containing fuel in 1977. Successful operation of the Shippingport LWBR might permit conversion of operating or presently planned pressurized-water reactors to thorium-containing LWBR cores.

A comprehensive study of the thorium fuel cycle in power reactors was conducted[16] by ERDA during 1976; results were published in early 1977. Initial findings indicated that the use of the thorium-fuel cycle in thermal reactors would result in better uranium utilization, and in some cases, better economic performance, as well as add flexibility to the nuclear industry in case of delays in development of fast-breeder reactors. A mixed uranium/thorium fuel cycle would have the added advantage of permitting a "denaturing" of recycled fissile fuels, since U_{233} can be diluted with U_{238}.

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[12]Charlot, G. (assigned to Société Française D'Electrometallurgia, Paris). Process for Treatment of Pyrochlore Concentrates. U.S. Pat. 3,947,542, Dec. 7, 1973.

[13]U.S. Nuclear Regulatory Commission. News Releases. V. 2, No. 26, June 29, 1976.

[14]Chemical Engineering Progress. Effects of Thorium Exposure To Be Studied. V. 72, No. 10, October 1976, p. 20.

[15]General Atomic Co. Quarterly Progress Report for the Period Ending May 31, 1976. Thorium Utilization Program. June 30, 1976, 226 pp.

[16]Kasten, P. R., Homan, F. J. Assessment of the Thorium Fuel Cycle in Power Reactors. Energy Research and Development Administration, ORNL/TM-5565, January 1977, 44 pp.

Tin

By Keith L. Harris[1]

As the world economy recovered from the 1975 recession, tin demand increased, resulting in higher prices and higher world tin mine production. At the end of June, 15 months after initiation, export controls were removed from member producing nations by the International Tin Council (ITC). The ITC price range was revised upwards a record three times during the year, providing 19% and 20% rises in the floor and ceiling prices, respectively. Over 19,000 metric tons[2] of the ITC buffer stock was sold during the year in an effort to defend the ceiling price.

U.S. consumption of primary and secondary tin increased 13% in 1976 to 62,928 tons. The major uses for tin were in tinplate, 33%; solder, 28%; bronze and brass, 12%; chemicals, 9%; and babbitt, 4%. Most of the Nation's tin, in the form of slabs, bars, and ingots, was imported from Malaysia, Bolivia, and Thailand. Less than 100 tons of tin came from mines in Colorado and New Mexico. About 18% of the tin consumed in the United States in 1976 was reclaimed from scrap.

The only primary tin smelter-refinery operating in the United States in 1976 was the Texas City, Tex., facility of Gulf Chemical & Metallurgical Co. (GCMC). The major feed to the smelter was tin concentrate from Bolivia's state-owned Corporación Minera de Bolivia (COMIBOL).

The average price of Straits (Malaysian) tin for New York delivery in 1976 was 379.82 cents per pound, 40 cents above the 1975 level. The Bureau of Mines changed to a composite price[3] in 1976, so the two annual averages are not directly comparable.

On September 15 the U. S. Senate ratified the treaty authorizing U.S. membership in the Fifth International Tin Agreement (ITA). The United States signed the Agree-

[1]Physical scientist, Division of Nonferrous Metals.
[2]Unless otherwise specified, all units are metric tons of contained tin.
[3]See price section for explanation.

Table 1.—Salient tin statistics

(Metric tons)

	1972	1973	1974	1975	1976
United States:					
Production:					
Mine	W	W	W	W	W
Smelter	4,369	4,877	6,096	6,500	5,700
Secondary	20,504	20,806	19,200	r15,869	16,446
Exports (including reexports)	1,152	3,461	8,550	3,596	2,338
Imports for consumption:					
Metal	53,293	46,581	40,238	44,366	45,055
Ore (tin content)	4,284	4,875	5,971	6,415	5,733
Consumption:					
Primary	54,360	59,075	52,439	43,620	51,767
Secondary	15,952	16,763	13,341	12,180	11,161
Prices, average cents per pound:					
Straits tin, in New York	177.47	227.56	396.27	339.82	379.82
Straits tin, ex-works Penang	168.24	214.10	355.72	303.55	338.94
World Production:					
Mine	244,183	237,847	r232,880	r224,180	225,755
Smelter	240,124	233,874	r236,198	r230,596	228,856

rRevised. W Withheld to avoid disclosing individual company confidential data.

ment on October 28, marking the first time the United States had joined a metal commodity agreement.

Legislation and Government Programs.— The General Services Administration (GSA) continued commercial sales of tin during the year. Sales totaled 3,643 tons, while shipments totaled 2,638 tons. The stockpile goal was lowered during the year from 41,150 tons to 33,021 tons. At yearend, there was an excess of 173,529 tons, of which 2,704 tons was authorized for sale by Congress. Several bills were introduced in Congress to authorize additional tin disposal from the Government stockpile, but none was enacted.

The depletion allowance for tin remained 22% for domestic deposits and 14% for foreign deposits.

Maine and Michigan passed legislation during the year that imposed deposits on disposable containers sold in those States. Oregon and Vermont were the only other States that had similar legislation. The legislation could decrease the use of disposable tinplate cans for beverages.

DOMESTIC PRODUCTION

PRIMARY TIN

Mine Production.— Domestic production of tin in 1976 was less than 100 tons. Most of the year's output came from Colorado as a byproduct of molybdenum mining. Some tin concentrate was produced at a placer operation in New Mexico.

Smelter Production.— The only domestic tin smelter, GCMC, received 5,733 tons of tin-in-concentrate from Bolivia, which formed the base feed together with domestic tin concentrate and secondary tin-bearing materials. Tin production was estimated at 5,700 tons.

SECONDARY TIN

The United States is the world's largest producer of recycled, or secondary, tin. Secondary tin furnishes about a quarter of the total U.S. supply each year. In 1976, secondary tin production increased 4% from the 1975 level to 16,446 tons. Of the tin recycled in 1976, 91% was as an alloy constituent of reclaimed bronzes, brasses, solders, and bearing and type metals, or as an element in chemical compounds. Only 9% of the recycled tin, mostly from new tinplate scrap, was reclaimed as metal.

Table 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1975	1976
Tinplate scrap treated metric tons	[r]651,244	685,450
Tin metal recovered in the form of—		
Metal do	1,146	1,195
Compounds (tin content) do	670	424
Total[1] do	1,816	1,619
Weight of tin compounds produced do	1,344	1,348
Average quantity of tin recovered per metric ton of tinplate scrap used kilograms	[r]2.79	2.36
Average delivered cost of tinplate scrap per metric ton	[r]$71.16	$67.26

[r]Revised.

[1]Recovery from tinplate scrap treated only. In addition, detinners recovered 250 metric tons (368 tons in 1975) of tin as metal and in compounds from tin-base scrap and residues in 1976.

Table 3.—Tin recovered from scrap processed in the United States, by form of recovery

(Metric tons)

Form of recovery	1975	1976
Tin metal:		
At detinning plants	r1,513	1,445
At other plants	228	22
Total	r1,741	1,467
Bronze and brass:		
From copper-base scrap	r7,102	8,282
From lead- and tin-base scrap	42	37
Total	r7,144	8,319
Solder	4,414	4,513
Type metal	877	668
Babbitt	569	495
Antimonial lead	442	548
Chemical compounds	670	424
Miscellaneous[1]	12	12
Total	6,984	6,660
Grand total	r15,869	16,446
Value (thousands)	r$118,886	$137,710

rRevised.
[1]Includes foil, cable lead, and terne metal.

Table 4.—Shipments of metal cans[1]

(Thousand base boxes[2])

Type of can	1975	1976p	1976 change (percent)
FOOD AND BEVERAGE			
Fruit and fruit juices	13,235	12,754	-3.6
Vegetables and vegetable juices	24,490	21,895	-10.6
Dairy-based products	3,502	3,429	-2.1
Soft drinks	33,284	39,491	+18.6
Beer	52,593	50,604	-3.8
Meat and poultry	3,185	3,342	+4.9
Fish and other seafoods	2,308	2,196	-4.9
Coffee	3,523	3,549	+.7
Lard and shortening	2,017	2,228	+10.5
Baby foods	1,427	1,619	+13.5
Pet foods	6,057	6,121	+1.1
All other foods, including soups	14,440	13,983	-3.2
Total	160,061	161,211	+.7
NONFOOD			
Oils	2,306	2,465	+6.9
Paint and varnish	5,326	5,930	+11.3
Pressure packing (valve type)	4,814	5,086	+5.7
All other nonfood	4,556	4,917	+7.9
Total	17,002	18,398	+8.2
Grand total	177,063	179,609	+1.4
BY METAL			
Steel base boxes	133,610	130,264	-2.5
Short tons (thousand)	5,260	5,129	-2.5
Aluminum base boxes	43,453	49,345	+13.6

pPreliminary.
[1]Includes tinplate and aluminum cans.
[2]The base box, a unit commonly used in the tinplate industry, equals 31,360 square inches of plate, or 62,720 square inches of total surface area.

Source: U.S. Department of Commerce.

Table 5.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States, in 1976

(Metric tons)

Type of scrap and class of consumer	Gross weight of scrap						Tin recovered		
	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31			
			New	Old	Total		New	Old	Total
Copper-base scrap:									
Secondary smelters:									
Auto radiators (unsweated)	3,696	52,515	--	52,456	52,456	3,755	--	2,256	2,256
Brass, composition or red	4,781	52,640	11,157	42,008	53,165	4,256	426	1,549	1,975
Brass, low (silicon bronze)	556	2,566	1,109	1,505	2,614	508	--	12	12
Brass, yellow	4,629	43,224	4,509	37,418	41,927	5,926	16	371	387
Bronze	1,535	18,392	2,964	15,107	18,071	1,856	234	1,185	1,419
Low-grade scrap and residues	11,979	71,513	56,754	14,652	71,406	12,086	16	--	16
Nickel silver	714	2,763	324	2,475	2,799	678	3	20	23
Railroad-car boxes	294	1,794	--	1,680	1,680	408	--	80	80
Total	28,184	245,407	76,817	167,301	244,118	29,473	695	5,473	6,168
Brass mills:[1]									
Brass, low (silicon bronze)	3,932	41,693	41,693	--	41,693	3,652	--	--	--
Brass, yellow	21,669	224,100	224,100	--	224,100	23,897	117	--	117
Bronze	902	3,837	3,837	--	3,837	726	180	--	180
Nickel silver	6,558	30,655	30,655	--	30,655	4,135	--	--	--
Total	33,061	300,285	300,285	--	300,285	32,410	297	--	297
Foundries and other plants:[2]									
Auto radiators (unsweated)	1,098	8,888	--	9,306	9,306	680	--	418	418
Brass, composition or red	460	4,034	1,241	2,858	4,099	395	59	136	195
Brass, low (silicon bronze)	33	1,348	738	582	1,320	61	--	5	5
Brass, yellow	475	7,212	5,034	2,267	7,301	386	--	19	19
Bronze	76	599	70	473	543	132	5	36	41
Low-grade scrap and residues	84	--	58	--	58	26	--	--	--
Nickel silver	--	79	--	74	74	5	--	--	--
Railroad-car boxes	541	4,627	--	3,925	3,925	1,243	--	186	186
Total	2,767	26,787	7,141	19,485	26,626	2,928	64	800	864
Total tin from copper-base scrap	XX	XX	XX	XX	XX	XX	1,056	6,273	7,329
Lead-base scrap:									
Smelters, refiners, and others:									
Babbitt	140	3,144	--	3,053	3,053	231	--	415	415
Battery lead plates	49,127	625,243	--	625,058	625,058	49,312	--	863	863
Drosses and residues	28,892	141,530	137,095	--	137,095	33,327	2,648	--	2,648
Solder and tinny lead	196	9,748	--	9,603	9,603	341	--	1,490	1,490
Type metal	2,167	18,249	--	17,793	17,793	2,623	--	801	801
Total	80,522	797,914	137,095	655,507	792,602	85,834	2,648	3,569	6,217
Tin-base scrap:									
Smelters, refiners, and others:									
Babbitt	27	141	--	155	155	13	--	129	129
Block-tin pipe	5	73	--	73	73	5	--	73	73
Drosses and residues	132	1,473	1,444	--	1,444	161	789	--	789
Pewter	--	49	--	46	46	3	--	40	40
Total	164	1,736	1,444	274	1,718	182	789	242	1,031
Tinplate and other scrap:									
Detinning plants	--	--	685,450	--	685,450	--	1,869	--	1,869
Grand total	XX	XX	XX	XX	XX	XX	6,362	10,084	16,446

[r]Revised. XX Not applicable.

[1]Brass-mill stocks include home scrap, and purchased-scrap consumption is assumed equal to receipts; therefore, lines and total in brass-mill section do not balance.

[2]Omits "machine-shop scrap."

CONSUMPTION

Tin consumption recovered 13% from the abnormally low level in 1975 to 62,928 tons, but was still at its lowest level since 1938, excluding 1975. Primary consumption increased 19%, while secondary consumption decreased 8%. Consumption was up in most sectors, but declines were reported for babbitt, terne metal, type metal, and miscellaneous alloys. The largest increases were recorded in the consumption of tin in solder, up 2,653 tons; tinplate, up 1,897 tons; and chemicals, up 1,623 tons. U.S. brass mills consumed 751 tons of primary tin and 233 tons of secondary tin, compared with 1975 levels of 481 tons and 244 tons, respectively.

Table 6.—Consumption of primary and secondary tin in the United States

(Metric tons)

	1972	1973	1974	1975	1976
Stocks Jan. 1[1]	18,855	18,787	18,534	20,228	19,440
Net receipts during year:					
Primary	55,958	60,125	55,382	43,183	50,031
Secondary	2,842	4,089	2,285	2,699	2,019
Scrap	14,115	13,915	12,296	10,568	10,189
Total receipts	72,915	78,129	69,963	56,450	62,239
Total available	91,770	96,916	88,497	76,678	81,679
Tin consumed in manufactured products:					
Primary	54,360	59,075	52,439	43,620	51,767
Secondary	15,952	16,763	13,341	12,180	11,161
Total	70,312	75,838	65,780	55,800	62,928
Intercompany transactions in scrap	2,671	2,544	2,489	1,438	1,891
Total processed	72,983	78,382	68,269	57,238	64,819
Stocks Dec. 31 (total available less total processed)	18,787	18,534	20,228	19,440	16,860

[1]Stocks shown exclude tin in transit or in other warehouses on January 1, as follows: 1972— 142 tons; 1973— 986 tons; 1974— 823 tons; 1975— 70 tons; and 1976—123 tons.

Table 7.—Tin content of tinplate produced in the United States

(Metric tons)

Year	Tinplate waste-waste, strips, cobbles, etc., gross weight	Tinplate (all forms)		
		Gross weight	Tin content[1]	Tin per metric ton of plate (kilograms)
1972	455,403	4,269,658	21,408	5.0
1973	r473,590	r4,452,779	21,608	4.9
1974	399,947	r4,701,840	22,686	4.8
1975	336,967	r4,018,285	18,869	r4.7
1976	439,988	4,372,639	20,719	4.7

rRevised.
[1]Includes small tonnage of secondary tin and tin acquired in chemicals.

Table 8.—Consumption of tin in the United States, by finished product

(Metric tons of contained tin)

Product	1975 Primary	1975 Secondary	1975 Total	1976 Primary	1976 Secondary	1976 Total
Alloys (miscellaneous)	481	130	611	513	93	606
Babbitt	1,817	788	2,605	1,832	591	2,423
Bar tin	581	56	637	656	102	758
Bronze and brass	2,626	4,929	7,555	2,860	4,796	7,656
Chemicals	2,735	1,263	3,998	4,718	903	5,621
Collapsible tubes and foil	516	22	538	679	15	694
Solder	10,669	4,406	15,075	13,506	4,222	17,728
Terne metal	267	85	352	180	9	189
Tinning	1,879	17	1,896	2,284	18	2,302
Tinplate[1]	18,869	--	18,869	20,766	--	20,766
Tin powder	850	--	850	1,208	--	1,208
Type metal	76	189	265	66	150	216
White metal[2]	1,948	269	2,217	2,093	254	2,347
Other	306	26	332	406	8	414
Total	43,620	12,180	55,800	51,767	11,161	62,928

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1]Includes secondary pig tin and tin acquired in chemicals.
[2]Includes pewter, britannia metal, and jewelers' metal.

STOCKS

Plant stocks of pig tin declined 7% to 6,856 tons, or about a month-and-a-half supply. As the price of tin increased during the year, companies cut back inventories and purchased tin when the market price temporarily dropped. Plant stocks were highest in July at 7,435 tons. Tinplate mills held 60% of the plant pig tin stocks at yearend.

Table 9.—U.S. industry yearend tin stocks

(Metric tons)

	1972	1973	1974	1975	1976
Plant raw materials:					
Pig tin:					
Virgin	8,283	7,658	8,784	7,090	6,613
Secondary	258	343	312	317	243
In process[1]	10,246	10,533	11,132	12,033	10,004
Total	18,787	18,534	20,228	19,440	16,860
Additional pig tin:					
In transit in United States	452	986	823	70	34
Jobbers-importers	2,763	1,153	691	2,059	1,009
Afloat to United States	3,785	3,688	4,409	4,115	3,582
Total	7,000	5,827	5,923	6,244	4,625
Grand total	25,787	24,361	26,151	25,684	21,485

[1]Tin content, including scrap.

PRICES

The price of tin during the year was influenced by ITC-imposed export controls, buffer stock purchases and sales, speculation, currency hedge buying, and a slowly increasing world demand. Definite rises in the price occurred in anticipation of price level increases at the May, October, and December ITC meetings; after the ITC revealed that the buffer stock contained only 2,820 tons on June 30; during the suspension of buffer stock operations from June 30 to July 7 as the Fifth ITA entered provisionally into force; and on December 28 when the Bolivian Government announced it would not ratify the Fifth ITA.

The average annual price increased substantially from the depressed prices of 1975 as the world economy recovered from the recession. The average U.S. price of Straits tin for New York delivery was 379.82 cents per pound, compared with 339.82 cents per pound in 1975. The average Penang price for ex-works Straits tin was M$1,146.56 per picul[4] (338.94 cents per pound) compared with M$963.79 per picul (303.55 cents per pound) in 1975. The average price for cash tin, standard grade, on the London Metal Exchange (LME) was £4,242.40 per metric ton (347.42 cents per pound). All averages, except the U.S. average, were the highest ever recorded.

The Penang market started the year at M$957 per picul (283 cents per pound). Buffer stock purchases and export controls were necessary to support the price until late January when dealers, covering their short positions, initiated an upward trend that peaked at the high for the year of M$1,320 per picul (390 cents per pound) on July 8. Consumer and speculative demand was evident during the rise, necessitating the sale, through July, of over 17,000 tons of tin from the buffer stock in an unsuccessful defense of the ceiling price. After July, the price declined and remained in the upper sector of the ITC price range for several months. In November, prices began moving upward, possibly in anticipation of a higher ITC price range, which came into effect on December 9. The price then stabilized around M$1,250 per picul (370 cents per pound) until word of Bolivia's decision not to ratify the Fifth ITA moved the price at yearend up to M$1,318 per picul (390 cents per pound).

Beginning in 1976, Metals Week, the source of the Bureau of Mines U.S. tin price, discontinued quoting a daily New York spot price and initiated a composite price. The composite price represents a replacement cost to the consumer and not a spot price as had been previously quoted with the daily New York Metals Week price. The Metals Week annual New York spot price for tin was 30.5 cents less than the composite price in 1976.

Table 10.—Monthly prices of Straits tin for delivery in New York

(Cents per pound)

Month	1975			1976		
	High	Low	Average	High	Low	Average
January	378.25	336.00	363.76	319.94	312.44	313.97
February	375.25	368.50	372.07	338.28	319.44	327.49
March	370.25	363.25	366.04	354.79	337.17	347.20
April	362.50	345.75	354.10	361.17	346.81	355.46
May	345.50	339.25	342.54	385.28	360.25	375.11
June	347.75	334.50	342.48	401.50	369.39	389.32
July	346.25	327.00	333.22	434.26	407.37	422.94
August	337.50	325.75	331.82	423.54	392.42	403.53
September	333.50	314.50	322.77	403.46	388.78	396.38
October	324.50	319.00	321.95	411.13	394.01	400.44
November	331.00	313.00	324.03	417.13	397.53	407.78
December	307.25	300.75	303.07	439.45	410.83	418.17
Average	378.25	300.75	339.82	439.45	312.44	379.82

Source: Metals Week. Beginning in 1976, prices are reported as a composite price.

FOREIGN TRADE

Exports of tin declined 35% from the 1975 level to 2,338 tons, a more normal level than that existing since 1973 when GSA commenced tin sales. Reexports continued to be larger than exports, as has been the case since 1975.

Imports of tin-in-concentrate, all from Bolivia, declined 11% as Bolivian labor problems caused a drop in shipments during the first quarter of the year.

Tin metal imports have always been the predominant portion of U.S. supply and 1976 was no exception. Of the 45,055 tons of tin metal imported, Malaysia supplied 60%; Thailand, 15%; Indonesia, 11%; and Bolivia, 4%. Imports of tin from the People's Republic of China dropped substantially from the

[4]One picul = 133.33 pounds. One ringget (M$) = US$0.39414 in 1976, US$0.4200 in 1975.

Table 11.—U.S. exports and imports for consumption of tin, tinplate, and terneplate in various forms

Year	Ingots, pigs, and bars				Tinplate and terneplate				Tinplate circles, strips, and cobbles		Tinplate scrap	
	Exports		Reexports		Exports		Imports		Exports		Imports	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1974	6,003	$47,774	2,547	$15,700	434,806	$166,843	289,389	$98,349	15,781	$2,654	11,471	$861
1975	1,444	10,457	2,152	15,531	232,052	105,870	370,508	170,191	2,574	437	11,138	786
1976	540	2,998	1,798	13,967	333,954	131,364	282,928	108,308	15,279	1,949	10,506	596

Table 12.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin and manufactures				Tin compounds	
	Imports			Exports	Imports	
	Tinfoil, tin powder, flitters, metallics, tin and manufactures, n.s.p.f.	Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f.		Tin scrap and other tin-bearing material, except tinplate scrap	Quantity (metric tons)	Value (thousands)
	Value (thousands)	Quantity (metric tons)	Value (thousands)	Value (thousands)		
1974	$9,331	1,789	$1,186	$5,950	189	$1,316
1975	7,257	2,468	2,452	4,343	122	823
1976	8,148	2,666	3,550	7,391	176	1,195

Table 13.—U.S. imports for consumption of tin, by country

Country	1975		1976	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Concentrates (tin content):				
Bolivia	6,415	$44,114	5,733	$38,529
Metal:[1]				
Australia	325	2,176	198	1,417
Austria	--	--	18	123
Bolivia	149	1,185	1,978	14,181
Brazil	615	4,193	1,242	9,025
Canada	7	59	7	60
China, People's Republic of	6,378	39,761	1,727	13,195
Germany, West	45	310	200	1,590
Hong Kong	200	170	84	491
India	--	--	100	868
Indonesia	4,371	29,823	4,972	35,160
Japan	31	203	--	--
Korea	--	--	21	124
Malaysia	23,920	177,359	26,981	196,454
Netherlands	--	--	(2)	2
Nigeria	59	454	--	--
Peru	145	1,520	--	--
Singapore	46	484	15	102
Switzerland	20	179	--	--
Taiwan	182	1,241	100	637
Thailand	7,422	50,290	6,885	47,903
United Kingdom	451	2,939	284	2,149
Uruguay	--	--	193	1,588
Vietnam	--	--	50	384
Total	44,366	312,346	45,055	325,453

[1]Bars, blocks, pigs or granulated.
[2]Less than 1/2 unit.

1975 level of 6,378 tons to 1,727 tons in 1976. A downward trend in imports from the People's Republic of China was expected as the internal demand of a new tinplate line lowered the tin available for export.

Small tonnages of secondary tin enter the United States as alloy constituents in recyclable solders or other alloys, or as tinplate or other scrap, dross, skimmings, and residues. These imports are included in secondary production figures and account in part for the differences encountered between U.S. production and consumption of secondary tin. Imports and exports of tin in alloy such as babbitt, solder, type metal, and bronze are shown in the Minerals Yearbook chapters on copper and lead. Ferrous scrap exports, including those of tinplate and terneplate scrap, are not classified separately.

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

During the year the ITC used all resources available to it in an effort to obtain market stabilization. Export controls had been imposed on member producing nations on April 18, 1975, and remained in effect until mid-1976. The buffer stock held 20,071 tons on December 31, 1975, and purchases continued through January 1976.

By the March quarterly meeting, the tin price had moved into the upper sector of the price range in response to increased demand and general optimism evident in all nonferrous metal markets. Because of increased mining costs, producers initiated and received an increase in the floor price of M$50 as of March 12. Export controls were not removed. By April 22, pressure on the ceiling price caused the ITC to schedule a special May session.

Meanwhile, Bolivia decided not to ratify the Fifth ITA by the April 30 deadline, claiming the ITC price range for tin was not high enough to cover Bolivian mining costs. A delegation headed by the ITC chairman went to Bolivia and persuaded the Government to announce its intent to ratify the agreement by April 30.

At the special May session, the price range was raised for the second time in the year, and the export quota for the second quarter was increased from 35,000 to 40,000 tons.

Export controls were removed June 30 during the June ITC meeting. The ITC revealed that the buffer stock held only 2,820 tons on June 30 and suspended its operations until a buffer stock was reestablished under the Fifth ITA. Consequently the price of tin penetrated the ceiling to reach its high for the year.

Since Bolivia had not ratified the Fifth ITA by the deadline date, it went provisionally into force July 1. The United States became a member for the first time. The buffer stock manager was released from his obligation to sell tin at the ceiling price and was authorized to operate at his discretion when the tin price was above the ceiling.

In October, the price issue was raised again by the producers, but the council deferred a decision until cost data were provided by the producers. The data were submitted, and a price rise was granted on December 9, although the United States voted against it. A comparison of the ranges at the beginning and end of the year follows:

	Jan. 1, 1976		Dec. 31, 1976	
	M$ per picul	U.S. equivalent cents per pound	M$ per picul	U.S. equivalent cents per pound
Floor price	900	266	1,075	318
Lower sector	900-980	266-290	1,075-1,150	318-340
Middle sector	980-1,040	290-307	1,150-1,250	340-370
Upper sector	1,040-1,100	307-325	1,250-1,325	370-392
Ceiling price	1,100	325	1,325	392

Bolivia did not ratify the Fifth ITA during the year. The agreement could be provisional for only 1 year before it must be renegotiated. Definitive entry into force of the Fifth ITA required the signature of at least six producing nations that held over 950 of the 1,000 producer votes in the Fourth ITA. Bolivia held 179 votes.

Australia.— Tin production, up for the first time since 1972, totaled 10,364 tons for the year. Increased output by Australia's two largest producers, Renison Ltd., up 750 tons over that of 1975 to 4,533 tons, and Abminco N.L., up 321 tons to 1,691 tons, ended the downward trend.

Renison, a subsidiary of Consolidated Gold Fields Australia Ltd., mined 505,703 tons of ore and treated 494,339 tons of ore containing 1.24% tin during the year ending June 30. Recovery of metal dropped to 65.3% from 68.8% in the previous year because of the higher proportion of refractory ore in the concentrator feed. Proven and probable reserves increased 839,000 tons to 9.9 million tons, but the average grade decreased from 1.34% to 1.24%. Additional diamond drilling was planned in the Mount Lindsay, Tasmania, joint venture area. Results from the first five holes were encouraging. Renison joined with other companies to explore the Doradilla tin prospects, southwest of Bourke, New South Wales, and the Mount Moss tin prospect, northwest of Townsville, Queensland. A feasibility study by Mitsubishi Metals Corp. was commissioned by Renison for a 7,000-ton-per-year tin smelter to be located in Tasmania. The study will be concluded in 1977.

During the year the Aberfoyle Group reorganized, with Aberfoyle Tin Ltd. transferring all operating interests to Abminco (formerly Cleveland Tin N.L.) in exchange for shares in that company. As a result, Abminco N.L. became owner of the Ardlethan tin mine at Ardlethan, New South Wales, the Aberfoyle mines in northeastern Tasmania, and the Cleveland tin-copper mine at Luina, Tasmania, while Aberfoyle Ltd. became a holding company with a 61.06% interest in Abminco N.L.

The Cleveland mine returned to a 7-day workweek at the end of June when ITC export controls were removed. The mine treated 363,036 tons of ore with a 0.73% head grade of tin and a recovery of 56.95%. Reserves were down 175,000 tons to 1.7 million tons, and the average grade dropped to 0.79% from 0.82% in the previous year. Ardlethan mine production declined 130 tons to 1,180 tons during the year ending November 23, 1976. Ore reserves were down 10% to 1.8 million tons, but the grade increased to 0.59%. The company operated at a loss during the year.

Bolivia.— Tin mine production increased 4% over the 1975 level to 29,812 tons. Production by COMIBOL, at 20,540 tons, was down slightly, but medium and small mine production increased 15% and 32%, respectively, to 6,665 tons and 2,607 tons. Tin exports totaled 30,355 tons, 15% above 1975 exports. The tin exports, valued at $227.9 million, accounted for 37% of the value of total Bolivian exports and 60% of the value of mineral exports.

Bolivia announced a major capital investment program for the minerals sector. Investments totaling $621 million over the next 5 years were planned in mining and metal processing. By 1980, domestic tin-smelting capacity was expected to be 32,500 tons, and tin mine output to be 35,000 tons.

COMIBOL experienced a miners' strike in June, and settlement required a 30% wage increase to all employees. Also included was a $136 million social amenities and housing program. Although COMIBOL's reported costs to produce and market tin increased 25% to $3.80 per pound during 1976, profits reached $3 million on sales of $255.3 million compared with losses of $10.7 million on sales of $211.3 million in 1975.

The Catavi mine, the world's largest underground tin mine, produced 5,418 tons of tin. Golder Associates, Inc. completed a geological and prefeasibility study for conversion of the Catavi mine to an open pit operation. The preliminary study delineated 80 million tons of ore grading 0.3% tin, sufficient for 25 years of operation with a mill recovering 4,500 tons of tin per year in a 52% concentrate.

The Huanuni mine, COMIBOL's most profitable mine, produced 4,486 tons of tin during the year. Huanuni, located 50 kilometers southeast of Oruro, is next to the Playa Verde alluvial tin deposit, which will be jointly exploited by COMIBOL and London Tin (Malaysia) Bhd. in a $10 million dredging project.

The Caracoles mill was modernized to treat 8,500 tons of ore per month with a mill head of 1.8% tin. Production totaled 1,745 tons of tin-in-concentrate in 1976. Additional investment in mine extensions and mechanization was scheduled to increase production 40% over the next 2 years.

The Empresa Nacional de Fundiciones (ENAF) smelter produced 9,185 tons of tin metal during the year and exported 9,211 tons. Increased production at the Vinto smelter was the result of an increase in capacity from 7,500 tons per year to 11,500 tons per year beginning in January. Additional expansion to 20,000 tons per year was expected by April 1977. Work was started on a smelter to be located next to the Vinto high-grade smelter to treat 10,000 to 12,500 tons per year of low-grade tin ore.

China, People's Republic of.— Tin reserves in the People's Republic of China (PRC) were estimated to be 2.2 million tons.[5] Tin deposits occur in six of the PRC's Provinces, but the PRC has published quantities for only the Haifeng and Chaoan districts in Kwangtung. Each district was estimated to have reserves of more than 200,000 tons of tin metal. Exports of tin, at 6,458 tons, declined 50% from the 1975 level. The PRC has exported an average of 7,500 tons per year over the past 10 years. The new 100,000-ton electrolytic tinplate line at Wuhan, to be commissioned in 1977, will divert some of the exports to internal consumption.

Germany, East.— East Germany will expand its tin production by nearly 45% by 1980 through the use of the Soviet-developed Kivcet process. The electrothermic process may improve recoveries to as much as 70% of the tin content of the high-sulfide ores mined in the Erzgebirge region.

Indonesia.— Indonesia established new regulations for negotiating mining contracts, replacing those rescinded in 1972. No contracts had been signed in more than 4 years. The regulations provided for duty-free imports of equipment and materials, a corporate income tax of 35% for the first 10 years and 45% for the following 20 years, an additional 5% annual deduction for capital investment expenditures for the first 4 years of production, a 10% export tax, decreasing in relation to the amount of ore processed in Indonesia, and supervision by Bank Negara Indonesia of foreign exchange earnings from mining exports.

Perusahaan Negara Tambang Timah (P.N. Timah), Indonesia's State-owned tin mining enterprise, was restructured into a limited company called Perusahaan Terbatas Tambang Timah (P.T. Timah) to allow it greater autonomy of operation.

P.T. Timah awarded the design contract for a new seagoing bucket dredge, the *Bangka II*, to F.W. Payne & Son Ltd. The dredge, to be equipped with 0.62-cubic-meter buckets with a maximum dredging depth of 50 meters and annual throughput of 5.3 million cubic meters, was scheduled to be in operation by 1979. The dredge will produce about 1,500 tons of tin-in-concentrate per year.

Timah's Peltim smelter at Mentok, Bangka, began smelting all of Indonesia's tin mine production in April. Capacity expansion from 18,000 to 33,000 tons, completed in 1975, precluded the necessity of exporting concentrates to Malaysia for smelting.

P.T. Koba Tin, a joint venture owned 25% by the Indonesian Government and 75% by three Australian firms, operated three gravel pump mines in the southeast Bangka district. About 1,000 tons of tin-in-concentrate was produced in 1976. Two small 0.08-cubic-meter bucket dredges under construction in Malaysia were expected to begin operation in 1977. Reserves of 36,000 tons of tin have been blocked out at the property.

Billiton Exploratie Maatschappij Indonesia, B.V. (BEMI) ordered a $25 million, 0.85-cubic-meter bucket dredge to exploit its concession in the Pulau Tudjuh area. The dredge, designed by Mining & Transport Engineering B.V. and built by Jurong Shipyard Ltd., will begin operations late in 1978 and recover about 1,700 tons of tin per year.

P. T. Broken Hill Pty. Indonesia (BHP) completed the final stage of development at the Kelapa Kampit lode mine on Bilitung Island. Dewatering was completed, the underground workings were partially rehabilitated, and exploration for additional reserves continued. A feasibility study was to be completed for presentation to the Indonesian Government in 1977.

Malaysia.— Tin production was at its lowest level since 1964. A total of 63,401 tons was mined, 1% below the 1975 level. The State licensing policy and high taxation reportedly were the main factors in the continuing decline in Malaysia's tin output. At yearend there were 51 tin dredges, 724

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[5]Ikonnikov, A.B. Mineral Resources of China. Geol. Soc. of America, Boulder, Colo., 1976, 500 pp.

gravel pump mines, and 36 opencast, underground, and other miscellaneous mines in operation, reflecting an 11% decrease in total active mines from yearend 1975 levels. Gravel pump operations accounted for 50% of the concentrate produced; dredging, 36%; opencast mining, 4%; underground mining, 3%; and miscellaneous sources, 7%. The tin-mining labor force declined 7% to 36,828 workers at yearend.

Metal production, at 78,017 tons, was 6% below the 1975 level. Exports of metal increased to 82,164 tons over the 77,635 tons in 1975. Imports of tin-in-concentrate totaled 8,156 tons, down 56% from those of 1975 because of decreased imports from Burma and Indonesia.

Industry officials expressed concern over problems that curtailed prospecting activity and created a poor investment climate. Heavy taxation was a substantial deterrent. The tin industry, the most heavily taxed industry in Malaysia, paid export duties, export surcharges, and taxes on tin profits, development, and income. In some cases, these taxes were over 70% of gross mining profits. Delays in processing applications for mining leases and the possible rejection of lease renewal applications have been major contributors to declining production over the past 4 years. Streamlining the application process and reduced taxation have been recommended. Also, the new economic policy of 30% Malaysian participation in the national economy was reported to have had a negative effect on tin productivity.

A $6 million aerial and geochemical survey was to be conducted over 30,000 square kilometers in Kelantan and Pahang to locate new sources of tin and other minerals. The program, to be financed by the Canadian Government, will take about 3 years to complete.

Perbadanan Nasional Bhd.'s (Pernas) subsidiary, Pernas Securities (the Malaysian Government investment branch), through an expenditure of $68 million, became the major owner of the London Tin Corporation (LTC), the world's largest tin investment group and the largest holder of Malaysian tin mines. Pernas Securities established New Tradewinds (NTW) as a holding company to buy LTC. NTW exchanged shares with Charter Consolidated Ltd. for Charter's Malaysian interests. As a result, Pernas held 71.35% of NTW, and Charter held 28.65%. NTW has interests in 18 mining companies, mostly in Malaysia, but also in Thailand and Nigeria, that produced 27,322 tons of 70% to 75% tin concentrate in 1976, or about 8.5% of the world tin mine production. The LTC purchase was a major step in furthering the Malaysian Government's new economic policy of 70% domestic private ownership in the tin industry by 1990.

Ayer Hitam Tin Dredging Ltd. displaced Berjuntai Tin Dredging Bhd. as Malaysia's largest tin-producing company. Ayer Hitam's No. 2 dredge worked very rich deep ground for several months, thereby more than doubling production to 5,923 tons of tin concentrate in 1976. This was the highest tin production by any private tin-mining company in the world since nationalization of the large Bolivian tin-mining companies in 1952.

Berjuntai's production increased 8% to 4,215 tons of tin concentrate. The company's new No. 8 dredge began production in September. Both the No. 8 and the No. 7 dredges were working areas that have reserves for 18 years of production. Nos. 2 and 3 dredging areas have reserves for 12 years; No. 4, about 16 years; No. 5, 3.5 years; and No. 6, 23 years.

Malaysian Tin Dredging Ltd. produced 2,895 tons of tin concentrate in 1976, 4% above that of 1975. The Perak State Government approved the diversion of the Kinta River, which will result in a 140-hectare addition to the mining area. The additional reserves will increase the life of four of the company's five dredges to more than 10 years. Reserves for the other dredges were sufficient for 8 years of operation.

Southern Malaysian Tin Dredging Ltd., with production of 2,403 tons of tin concentrate during the year, completed the diversion of the Chenderiang River to limit flooding and to fulfill a condition of the mining lease for the Degong Road property. The ITC tin export control period required cutbacks of 84 dredging days at the Tanjong Tualong property and 43 days at the Degong Road property.

Austral Amalgamated Tin Bhd.'s production declined 16% from the 1975 level to 1,290 tons of tin concentrate owing to the closing of one of its three dredges after exhaustion of reserves. Kuala Kampar Tin Fields Bhd. was also forced to close one of its dredges when operations became uneconomic.

Although Pacific Tin Consolidated Corp., the only U.S. company mining tin in Malaysia, decreased tin production slightly in 1976, income before taxes increased 68% because of increased tin prices.

The Selangor State Development Corp.'s (SSDC) mining subsidiary, Syarikat Timah Langat, began trial operations of its first dredge. The 0.7-cubic-meter, $5 million dredge operated at a concession of 800 hectares at Dengkil in the Kuala Langat forest reserve.

Charter and its subsidiary company, Tronoh Mines Ltd., stopped exploration at its Kuala Langat concession joint venture with the SSDC after SSDC notified Charter it did not have funds to reimburse Charter for its share of the development costs. Political uncertainty and equity apportioning of the 55% SSDC-36% Charter-9% Tronoh joint venture were contributing factors in the cessation of operations.

Conzinc Riotinto Malaysian Sdn. Bhd. recovered 1,079 tons of tin at its single-dredge operation on a 550 hectare Kuala Langat concession. It joined with the Pahang Tenggara Developent Authority in a 30%-70% joint venture to explore for tin and other metals in Pahang Tenggara.

Nigeria.— Tin production continued to decline for the eigth consecutive year to 3,710 tons in 1976, the lowest level since the Bureau of Mines began publishing world production data in 1921. Increased costs for fuel, power, and labor continued to plague the Nigerian tin industry.

Forty percent of Amalgamated Tin Mines of Nigeria (Holdings) Ltd. (ATMN), Nigeria's largest tin-mining company, was sold to the state-owned Nigerian Mining Corporation (NMC). The acquisition was aimed at giving Nigeria a voice in the exploitation and expansion of mining operations. Although ATMN reported an increase in production of 156 tons from the previous fiscal year, the proceeds in terms of Nigerian currency were considerably lower. Work began in mid-November on ATMN's Sabon Gida tinfield. Due to the depth of the deposit and the time needed to move the overburden, tin production was not expected until mid-1977.

Gold & Base Metal Mines of Nigeria Ltd., continued development at its Liruie prospect in Kano State at a reduced level while an agreement was reached on the formation of a new company, Ririwai Mines Ltd. NMC was the major shareholder, with Gold & Base retaining 20%. A mine is to be established with a treatment plant capable of processing 900 tons of ore per day. Production was expected to start in 1979.

South Africa, Republic of.— The country's three tin producers continued to mine tin at about the same rate as in 1975. Rooiberg Minerals Development Co. Ltd. operated four mines at the Rooiberg tin field 56 kilometers west of Warmbaths that produced 3,710 tons of tin concentrate. The decreasing grade of ore mined at the Hartebeestfontein mine ("A" mine) was offset by an increase in grade of ore treated at the Leeuwpoort mine ("C" mine). Surface drilling at the "A" mine delineated a new medium grade area that may be amenable to open pit mining.

Union Tin Mines Ltd. produced 1,619 tons of concentrate during the year, up 2% over the 1975 level. Underground reserves were estimated to provide another year of production, depending upon the tin price, but reworking of the tailings dam may extend the mine's life into 1978.

Zaaiplaats Tin Mining Co. Ltd., South Africa's smallest tin producer, was installing a small ball mill to increase milling capacity. Production was down slightly to 303 tons of tin concentrate in 1976.

Thailand.— Illegal mining by suction boat operations became less of a problem in 1976 after the Government allowed the boats to operate in the near-shore portion of the concessions of the nationalized Thailand Exploration and Mining Co., Ltd. (Temco). The independent miners were required to register their operations and sell their output to the Government. Thailand's official production increased 4,000 tons over the 1975 level to 20,453 tons, with the suction boat operations producing 4,683 tons.

After numerous false starts and frequent changes in political leadership, the Thai Government and Billiton reached a production-sharing agreement over the nationalized Temco concessions. The 5-year agreement, with provisions for an extension, allows a 69% Billiton - 31% Thai Government split of profits on production under 1,300 tons per year, a 50%/50% split of profits on production over 1,500 tons per year, and a 40%/60% split of profits on production over 1,700 tons per year.

Aokam Tin Bhd., Southern Kinta Consolidated Ltd., and Tongkah Harbour Tin Dredging Bhd., all owned by LTC, were closed by illegal strikes late in January. Operations at Aokam and Tongkah Harbour resumed in April after a new agreement was negotiated with the labor union. Southern Kinta did not resume operations during the year owing to lease difficulties. Aokam, the largest tin producer, mined 2,441 tons of tin concentrate in 1975 but only 1,490 tons in 1976. Combined production of Southern Kinta and Tongkah Harbour was only 448 tons of concentrate in 1976, compared with 1,337 tons in 1975.

United Kingdom.— Although mine production declined 7 tons from the 1975 level to 3,323 tons in 1976, the outlook for the United Kingdom's tin mining industry improved as a result of higher tin prices. Domestic tin production accounted for 25% of the country's primary demand. The Cornish Chamber of Mines felt production could increase if the Government initiated mineral rights legislation enabling mining companies to prospect or mine in Cornwall.

At St. Piram Ltd.'s South Crofty mine, the country's largest tin mine, a $1.4 million investment program neared completion. An underground haulage system was installed, and a second underground crusher was installed at the 658-meter level. The Dolcoath North lode was opened up on four levels, adding to ore reserves. Continued development work was expected to bring production up to 2,800 tons in 2 years. The Simms shaft at St. Piram's Pendarves mine was deepened, and cross-cutting to the Tryphena lode started. Development continued to improve mine ventilation. Production at both of St. Piram's Cornwall mines totaled 1,541 tons of tin-in-concentrate.

Wheal Jane Ltd.'s production continued to decline, with output of tin-in-concentrate down 11% from that of 1975. Low tin prices in 1975 limited cash flow, thereby interrupt-

Table 14.—Tin: World mine production, by country[1]

(Metric tons)

Country	1974	1975	1976[p]
North America:			
Canada	[r]324	319	275
Mexico	400	378	481
United States	W	W	W
South America:			
Argentina	[r]556	538	[3]600
Bolivia[2]	29,498	28,735	29,812
Brazil	[r] [3]4,400	[r] [3]5,000	5,900
Peru	155	153	273
Europe:			
Czechoslovakia	143	176	[3]180
France	142	49	--
Germany, East[e]	1,120	1,120	1,120
Portugal	424	375	354
Spain	643	737	390
U.S.S.R.[e]	29,500	30,000	31,000
United Kingdom	3,827	3,330	3,323
Africa:			
Burundi[3]	100	100	100
Cameroon	19	19	[e]19
Morocco	4	--	[3]--
Niger	79	98	[e]91
Nigeria	5,455	4,652	3,710
Rhodesia, Southern[3]	600	600	600
Rwanda[3]	1,300	1,250	1,200
South Africa, Republic of	2,542	2,643	2,784
South-West Africa, Territory of	781	760	735
Swaziland[3]	[r]1	[r]1	--
Tanzania	11	2	3
Uganda	199	[3]117	[3]120
Zaire	[r]4,675	4,562	[3]4,000
Zambia[3]	11	10	10
Asia:			
Burma[3]	[r]600	[r]750	750
China, People's Republic of[e]	20,000	22,000	20,000
Indonesia	25,021	24,391	22,204
Japan	548	659	643
Korea, Republic of	14	4	35
Laos	594	518	[3]576
Malaysia	68,124	64,364	63,401
Thailand	20,339	16,406	20,452
Vietnam[e]	250	250	250
Oceania: Australia	[r]10,481	9,114	10,364
Total	[r]232,880	224,180	225,755

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data.

[1]Contained tin basis. Data derived in part from the Monthly Statistical Bulletin of the International Tin Council, London, England.

[2]Total of COMIBOL output, including COMIBOL purchases from lessees operating in COMIBOL mines and medium and small mines' sales to ENAF plus their exports.

[3]Estimate by the International Tin Council.

ing Wheal Jane's development program and resulting in the lower output. The company obtained a loan of $6.8 million, 60% of which was provided interest-free by the Government, to finance a 3-year development for driving additional access tunnels and improving the efficiency of the concentrator.

Geevor Tin Mines Ltd. obtained a $900,000 low-interest loan to continue its 5-year expansion plan. Geevor mined 110,354 tons of ore during the year, recovering 948 tons of 65% tin concentrate.

Production began in February at the Mount Wellington mine of Cornwall Tin & Mining Ltd., but the mine operated only at about 30% of capacity during the year owing to water seepage and labor problems. Ore reserves were over 1 million tons with a tin content of 1.35%. The capacity of the mill was 200,000 tons of ore per year, yielding 1,600 tons of tin per year.

Zaire.— The final phase of company mergers in the Kivu Province took place in February. Cobelmine-Zaire and Syndicat Minière de l'Etain (Symetain) combined to form Société Minière et Industrielle du Kivu (Sominki). The Zairian Government held a 20% interest in the company. Sominki produced 3,315 tons of tin in concentrate in 1976.

Table 15.—Tin: World smelter production, by country[1]

(Metric tons)

Country	1974	1975	1976[p]
North America:			
Mexico[2] [3]	1,200	1,000	800
United States[4]	6,096	6,500	5,700
South America:			
Argentina[2]	120	120	120
Bolivia[5]	[r]7,049	7,533	9,185
Brazil[2]	4,850	5,400	6,600
Europe:			
Belgium	3,418	4,562	4,068
Czechoslovakia	120	[2]108	[e]110
Germany, East[e]	[r]1,200	[r]1,200	1,200
Germany, West	1,384	1,306	1,449
Portugal	450	409	355
Spain	6,160	8,042	5,368
U.S.S.R.[e]	29,500	30,000	31,000
United Kingdom	[r]20,404	11,520	9,848
Africa:			
Morocco[2]	[r]5	([6])	--
Nigeria	5,574	4,677	3,667
Rhodesia, Southern[2]	600	600	600
South Africa, Republic of	854	780	683
Zaire	[r]1,016	648	[2]600
Asia:			
China, People's Republic of[e]	20,000	22,000	20,000
Indonesia	15,066	17,825	22,202
Japan	1,328	1,212	1,144
Malaysia	[r] [7]83,063	83,070	78,017
Thailand	19,827	16,630	20,337
Vietnam[e]	200	200	200
Oceania: Australia	6,714	5,254	5,603
Total	[r]236,198	230,596	228,856

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Data derived in part from the Monthly Statistical Bulletin of the International Tin Council, London, England.
[2]Estimate by the International Tin Council.
[3]Smelter output from domestic ores is as follows in metric tons: 1974— 400; 1975— 378; 1976— 481.
[4]Includes tin content of alloys made directly from ores.
[5]Tin content of production from Metabol and Peru smelters plus exports by ENAF smelter.
[6]Revised to zero.
[7]Includes small production of tin from smelter in Singapore.

TECHNOLOGY

The Institution of Mining and Metallurgy sponsored a meeting in London on tin technology and economics.[6] Papers were presented on surface and underground production, tin ore treatment, smelting, refining, marketing, and uses of tin, impact of substitution, and tin supply and demand.

A process was developed for recovering underground sulfidic or oxidic ores of tin in metallic form.[7] Electric induction heating by alternating current was used to melt and break the ore, yielding metal which was pneumatically pumped to the surface.

A sled for recovering sedimentary tin from the ocean floor was developed.[8] The sled incorporated a bucket elevator mechanism that was loaded from a concentrate collector on the sled and emptied onto a surface vessel.

Continued research on froth flotation beneficiation of tin yielded several patentable processes.[9] One process, requiring relatively low-cost reagents, uses a coarser feed than usual and has increased yield. Flotation can take place between pH 2.0 and 8.0 in the presence of alcohols and/or oils as frothers and sodium hexafluorosilicate or sodium silicate as a suppressant. Another method uses a cyanide reducing agent to lower the valence state of the tin-containing particles, improving their floatability in the presence of an olefin alcohol or propargyl carbinol collector agent.

Australia's Commonwealth Scientific & Industrial Research Organization (CSIRO) developed a highly efficient method of processing low grade (20% to 30%) tin concentrates.[10] The submerged combustion process uses a double tubed lance to inject reductants and air below the surface of the molten concentrate. CSIRO claimed the process is at least 20 times faster and more energy efficient than conventional melting techniques.

The International Tin Research Council sponsored the First International Conference on Tinplate.[11] Papers on marketing, production, canmaking, can performance, lacquering, quality control, and metals reclamation were presented.

Bethlehem Steel Corp. developed an organic-coated blackplate.[12] It was stated that although the process was not competitive with 0.25-pound-per-base-box tinplate when coated at a toll coater's facility, it was competitive when coated at the end users inhouse facility. A single-side organic-coated blackplate would offer a savings over the 0.25-pound-per-base-box tinplate whether coated inhouse or by a toll coater.

A new miticide based on bis (trineophyltin) oxide for controlling a wide range of plant-feeding mites became commercially available.[13] Research on lead-calcium-tin alloys for use in maintenance-free batteries was summarized, and commercial applications of such alloys were discussed.[14] Lead-copper-tin batteries offer prolonged shelf life, and reduced battery failure due to positive grid oxidation. They require no water additions in normal circumstances.

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[6]Mining Magazine. Tin-Technology and Economics. V. 136, No. 2., February 1977, p. 93; available from the Institution of Mining and Metallurgy, 44 Portland Place, London W1N 4BR, England.

[7]Tin International. Tin Recovery Processes. V. 50, 1977, p. 131.

[8]Tin International. Tin Recovery Processes. V. 49, 1976, p. 426.

[9]Engineering and Mining Journal. Patents. V. 178, No. 3, March 1977, p. 238.
Tin International. Tin Recovery Processes. V. 49, 1976, p. 200.

[10]Tin International. New Australian Smelting Process. V. 49, 1976, p. 304.

[11]International Tin Research Institute. First International Tinplate Conference, London, England, Oct. 5-8, 1976. ITRA Pub. No. 530, 464 pp.

[12]VanderVern, P.J., D.C. Shah, G.A. Perfetti, and H. Darlington. Coated Blackplate: Steel's Salvation in Beverage Cans? Mod. Metals, v. 32, No. 12, January 1977, pp. 60-64.

[13]Evans, C.J. A New Organotin Miticide. Tin and Its Uses, Quarterly Review (Tin Res. Inst.), No. 110, 1976, pp. 6-7.

[14]Dinsdale, P.M. Lead-Calcium-Tin Alloys for the Lead-Acid Battery. Tin and Its Uses, Quarterly Review (Tin Res. Inst.), Part 1, No. 110, 1976, pp. 12-14; Part 2, No. 111, 1977, pp. 13-15.

Titanium

By Langtry E. Lynd[1]

U.S. production of titanium sponge metal in 1976 was 41% less than in 1975. Consumption of sponge metal was 13,315 tons, down 24% from that of 1975. Ingot production and consumption were each about 21,000 tons in 1976 or about 15% less than in 1975. Sponge inventories dropped from 5,669 tons to 3,617 tons, and scrap metal consumption increased from 8,316 tons in 1975 to 9,211 tons in 1976. Titanium dioxide pigment production was about 713,000 tons, 18% higher than in 1975. Pigment imports increased to about 70,000 tons from about 16,000 tons in 1975, probably due to larger imports by NL Industries, Inc., from its European subsidiaries to offset limited production at Sayreville, N.J.

Domestic ilmenite production declined during 1976 for the third consecutive year to 652,404 tons, down 9% from 1975 production. However, imports of ilmenite, natural rutile, and synthetic rutile increased 38%, 18%, and 48%, respectively. Titanium slag imports were 19% below the 1975 level.

The main price changes during 1976 were a decrease in the price of rutile to $A230 to $A240 per metric ton ($244 to $254 per short ton) f.o.b. Australian ports; an increase in the price of QIT slag to $90 per long ton f.o.b. Sorel, Quebec; a 3-cent-per-pound increase in the price of titanium dioxide pigments to 46.5 cents per pound for rutile and 41 cents per pound for anatase; and a decrease in the price of imported sponge from about $2.70 to $2.45-$2.50 per pound.

Legislation and Government Programs.—In June, the Federal Preparedness Agency, General Services Administration, reinstated a stockpile objective for titanium sponge metal at 32,329 short tons. In October, the Agency recommended a new stockpile goal of 131,503 tons, based on 3-year

[1]Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient titanium statistics

	1972	1973	1974	1975	1976
United States:					
Ilmenite concentrate:					
Mine shipments ______ short tons__	739,801	804,355	755,338	702,252	617,896
Value ____________ thousands__	$16,739	$20,128	$22,715	$26,946	$27,578
Imports ____________ short tons__	14,836	69,641	82,448	122,010	168,402
Consumption _____________ do__	786,384	807,733	851,977	747,821	822,259
Titanium slag:					
Imports _________________ do__	298,259	237,248	236,272	212,682	171,624
Consumption _____________ do__	264,095	281,791	257,125	147,965	203,964
Rutile concentrate, natural and synthetic:					
Imports _________________ do__	220,533	226,860	246,489	224,499	281,712
Consumption _____________ do__	242,758	276,907	292,661	231,430	237,718
Sponge metal:					
Imports for consumption _____ do__	3,808	5,172	6,963	4,190	1,778
Consumption _____________ do__	13,068	20,173	26,896	17,626	13,315
Price: December 31, per pound ________________	$1.32	$1.42	$2.25	$2.70	$2.70
World production:					
Ilmenite concentrate _____ short tons__	2,702,398	2,983,123	r3,518,640	3,217,943	3,511,556
Titanium slag _______________ do__	924,084	947,394	936,023	831,506	911,043
Rutile concentrate, natural ______ do__	351,380	385,284	r397,765	[1]416,775	[1]471,053

rRevised.
[1]Excludes U.S. production data in order to avoid disclosing individual company confidential data.

war criteria for establishing stockpile objectives. The quantity of specification titanium sponge metal in the Government stockpile in December 1976 was 27,853 tons. In addition, there was 4,476 tons of nonspecification material.

In October, the Government stockpile goal for rutile ore was set at 173,928 tons and total rutile stockpile inventory in December 1976 was 39,186 tons.

In December 1976, the Antitrust Division, U.S. Department of Justice, began an investigation of price fixing in the titanium metal industry, following voluntary disclosure by NL Industries, Inc., that certain employees of its affiliate, Titanium Metals Corporation of America (TMCA), had discussed titanium pricing with competitors during the period 1971 to early 1976.

Plans for the proposed B-1 strategic bomber raised expectations that titanium metal demand would increase significantly, because each of the planned 241 aircraft would require about 175,000 pounds of titanium. The whole B-1 program would probably require over 20,000 tons of ingot and would consume about 5% to 10% of annual U.S. mill product production for several years.

DOMESTIC PRODUCTION

Concentrates.—Production and shipments of ilmenite concentrate decreased 9% and 12%, respectively, in 1976, the third consecutive yearly decline for both categories. Titanium dioxide contained in concentrates shipped was 7% less than in 1975, although the average TiO_2 content increased from 57.6% in 1975 to 60.7% in 1976. A 98% increase in production at the Titanium Enterprises mine, Green Cove Springs, Fla., and increases of 9% and 45% from the mines of ASARCO Incorporated and SCM Corp., Glidden-Durkee Div., both near Lakehurst, N.J., were insufficient to offset decreases at the mines of NL Industries, Inc., Tahawus, N.Y., and Humphreys Mining Co., Boulogne, Fla. Production at the E. I. du Pont de Nemours & Co., Inc., mines, Starke and Highland, Fla., increased about 3%. The large decrease in production at Tahawus resulted mainly from reduced demand because of the prolonged strike at the Sayreville, N.J. pigment plant.

Kerr-McGee Chemical Corp. completed construction of its synthetic rutile plant at Mobile, Ala., which has a reported production capacity of 110,000 tons per year. This plant was to provide feed material for a proposed new pigment plant to be built at Mobile with a capacity of 50,000 tons per year of titanium dioxide pigment and for a similar 10-year old pigment plant in Hamilton, Miss. The synthetic rutile plant was to initially consume ilmenite from Australia and employ the Benilite Cyclic Process, which involves partial reduction of ilmenite, leaching of the reduced ore with 18% to 20% hydrochloric acid to remove iron, and recovery of the acid from the spent liquor.

The U.S. Geological Survey announced discovery of a sand deposit of glacial origin, containing 31 million tons of ilmenite and a smaller quantity of rutile. However, the ilmenite occurs mainly in mixed grains, intergrown with silicate minerals and probably could not be recovered profitably under present economic conditions.[2]

A perovskite deposit in southwestern Colorado owned by Buttes Gas & Oil Co. was estimated to contain about 50 million tons

[2]New York Times. Titaniferous Ores Found on Adirondack Fringe. V. 125, No. 43,197, May 1, 1976, p. 40.
U.S. Geological Survey. Titanium Minerals Found in Upstate New York Sand Deposits. U.S. Geol. Survey News Release, Apr. 27, 1976, 2 pp.

Table 2.—Production and mine shipments of ilmenite concentrates[1] from domestic ores in the United States

Year	Production (short tons, gross weight)	Shipments		
		Short tons (gross weight)	TiO_2 content (short tons)	Value (thousands)
1972	677,944	739,801	417,553	16,739
1973	776,013	804,355	458,541	20,128
1974	744,571	755,338	434,605	22,715
1975	717,281	702,252	404,269	26,946
1976	652,404	617,896	374,989	27,578

[1]Includes a mixed product containing rutile, leucoxene, and altered ilmenite.

of TiO_2.[3] The deposit was also reported to contain a significant quantity of columbium, thorium, rare-earth elements, and apatite. Processes to convert the perovskite to titanium dioxide were being investigated and economic feasibility studies were being carried out.

Ferrotitanium.—Ferrotitanium was produced by Shieldalloy Corp. at Newfield, N.J., and by Reactive Metals and Alloys Corp. West Pittsburgh, Pa. As in the years prior to 1976, most of the production contained 40% titanium or higher.

Metal.—Production of titanium sponge metal in 1976 was 41% lower than in 1975. Ingot production was down about 15% from the 1975 levels.

Sponge producing companies were TMCA, Henderson, Nev., jointly owned by NL Industries, Inc., and Allegheny-Ludlum Steel Corp.; RMI Co., Ashtabula, Ohio, owned by National Distillers & Chemical Corp. and United States Steel Corp.; and Oregon Metallurgical Corp., Albany, Oreg., owned by Armco Steel Corp. and Ladish Corp., which resumed production late in 1976. The following 11 companies produced titanium ingot:

Company	Plant location
American Welding & Manufacturing Co	Warren, Ohio
Crucible, Inc., Colt Industries	Midland, Pa.
Howmet Corp.,[1] Alloy Division	Whitehall, Mich.
Lawrence Aviation Industries, Inc	Port Jefferson, N.Y.
Martin Marietta Aluminum, Inc	Torrance, Calif.
Oregon Metallurgical Corp	Albany, Oreg.
RMI Co	Niles, Ohio
Teledyne Allvac	Monroe, N.C.
Titanium Metals Corp. of America	Henderson, Nev.
Titanium West, Inc	Reno, Nev.
TiTech International, Inc	Pomona, Calif.

[1]Now a subsidiary of Pechiney Ugine Kuhlmann Corp.

Titanium West ceased production during 1976. American Welding and Lawrence Aviation began ingot production in 1976 and 1975, respectively.

Pigment.—Pigment production was 18% higher than in 1975. Shipments were up 24% and the value of shipments increased 40%. Rutile pigment accounted for 75% of total production and was produced by 6 manufacturers. Five companies produced anatase pigment. Companies producing titanium dioxide pigment during the year with plant location and nominal capacity in tons per year were as follows:

Company and plant location	Pigment capacity (tons per year)	
	Sulfate process	Chloride process
American Cyanamid Co., Savannah, Ga	50,000	50,000
E. I. du Pont de Nemours & Co., Inc.:		
Antioch, Calif	--	30,000
Edge Moor, Del	--	160,000
New Johnsonville, Tenn	--	235,000
Kerr-McGee Chemical Co., Hamilton, Miss	--	50,000
NL Industries, Inc.:		
St. Louis, Mo	100,000	--
Sayreville, N.J	125,000	--
New Jersey Zinc Co.:		
Gloucester City, N.J	42,000	--
Ashtabula, Ohio	--	30,000
SCM Corp., Glidden-Durkee Div.:		
Baltimore, Md	55,000	30,000
Ashtabula, Ohio	--	30,000
Total	372,000	615,000

Capital allocations of $40 million were made by Du Pont for preliminary work on a new chloride process pigment plant to be built at De Lisle, Miss. The plant was reported to have a planned capacity of 150,000 tons per year and was expected to be completed in 1979 at a cost of about $150

[3]Wall Street Journal. Buttes Says Studies on Colorado Prospect Indicate Major Deposit of Titanium Ore. V. 187, No. 37, Feb. 24, 1976, p. 6.

Table 3.—Titanium metal data

(Short tons)

	1972	1973	1974	1975	1976
Sponge metal:					
Imports for consumption	3,808	5,172	6,963	4,190	1,778
Industry stocks	1,816	1,941	3,822	5,669	3,617
Government stocks (total inventory)[1]	35,015	32,517	31,104	31,692	32,329
Consumption	13,068	20,173	26,896	17,626	13,315
Scrap metal:					
Consumption	7,802	10,038	10,599	8,316	9,211
Stocks	4,296	4,447	5,517	6,132	5,764
Ingot:[2]					
Production	20,267	28,932	36,132	25,560	21,614
Consumption	19,499	25,409	31,563	24,486	21,004
Stocks	NA	NA	NA	1,032	2,034
Net shipments of mill products[3]	12,627	14,530	17,443	15,628	14,498

NA Not available.
[1]As of December 31 each year.
[2]Includes alloy constituents.
[3]Bureau of the Census, Current Industrial Reports Series DIB-991.

Table 4.—Titanium pigment data

(TiO_2 content)

Year	Production (short tons)	Shipments[1]	
		Quantity (short tons)	Value, f.o.b. (thousands)
1972	693,281	725,059	$346,624
1973	784,996	793,991	404,639
1974	[r]786,672	759,068	513,409
1975	603,429	576,097	423,701
1976[p]	712,940	711,774	594,846

[p]Preliminary. [r]Revised.
[1]Includes interplant transfers.

Source: Bureau of the Census.

million. Du Pont's production of upgraded ferric chloride as a byproduct of pigment production at its Edge Moor, Del., plant was expected to reach close to its 150,000-ton-per-year ferric chloride capacity by the end of 1976. The company was reported to be upgrading and selling about 20% of its waste ferric chloride in solution form early in 1976 and planned to be selling around 80% of it by 1979. Ferric chloride is used in water purification.

NL Industries was planning to build a 100,000-ton-per-year pigment plant using its own chloride process which can utilize lower grade feed materials such as beneficiated ilmenite as well as rutile. A site in the Southeastern United States near the company's raw material sources was being considered. Start of construction was planned for 1979, following anticipated completion of a 40,000-ton-per-year chloride process plant at Leverkusen, West Germany, where NL also operates a sulfate process plant.

The strike at the NL Industries Sayreville, N.J., plant, which began in early February, was settled in December, but production was not resumed until mid-1977. The plant was operated by management and technical personnel at somewhat less than 50% of capacity until September 1976.

Kerr-McKee Chemical Co. planned to build a chloride process plant of 50,000 tons annual capacity at Mobile, Ala. The plant was to be supplied with feed material from the company's rutile plant that was completed at Mobile in 1976.

American Cyanamid Co. appealed a decision by a special hearing officer of the State of Georgia that the company could be fined up to $300,000 for continued pollution of the Savannah River by effluent from its Savannah, Ga., pigment plant. A State antipollution deadline had been set for December 31, 1972. The company claimed it was impossible to build a new waste treatment plant by the deadline. American Cyanamid did open a new waste treatment plant in August 1975, but had operational problems with the process that converts pigment plant waste into gypsum and a nonpolluting liquid effluent. In September 1977, the Georgia Supreme Court upheld a lower court decision overturning the fine that had been levied against the company.

CONSUMPTION AND USES

Concentrates.—Consumption of ilmenite, rutile, and titanium slag increased 10%, 3%, and 38%, respectively, from 1975 levels.

Metal.—Consumption of titanium sponge and ingot decreased 24% and 14%, respectively; scrap metal consumption increased 11%. Net shipments of mill products decreased 7% from the 1975 level, but the amount of castings shipped increased 7% to 257 tons. The quantity of pipe and tubing shipped, including other extrusions, increased 16% to about 2,800 tons. The most significant declines were in rod and bar shipments, off 22% at about 1,300 tons, and flat rolled products, down 15% to about 3,700 tons. Forging and extrusion billet shipments amounted to about 6,500 tons, down 7% from the 1975 level.

Aerospace applications, both military and commercial, continued to dominate the market for titanium metal with production of the McDonnell Douglas F-15 accounting for a substantial portion of mill product shipments. The use of titanium in chemical processing and other industrial applications continued to grow, but did not increase sufficiently to offset the decline in requirements of titanium for aerospace applications.

A major industrial use of titanium in 1976 was for powerplant surface condenser tubing, although growth in this area was slowed somewhat by cancellation or delay of construction of several nuclear power generating plants. Other industrial applications expected to continue to grow steadily include the use of titanium cathodes as starter sheets in the electrolytic refining of copper and use in other situations requiring high corrosion resistance; for example, pulp and paper industries, petrochemical and chemical industries, for storage tanks, reaction vessels, valves, pumps, and piping.

Pigment.—Preliminary figures showed a 24% increase in pigment shipments in 1976, recovering most of the decrease that occurred in 1975. Shortages, which might have developed because of low inventories, increased demand, and the strike at the NL Industries plant at Sayreville, N.J., were

Table 5.—Consumption of titanium concentrates in the United States, by product

(Short tons)

Year and product	Ilmenite[1]		Titanium slag		Rutile	
	Gross weight	TiO_2 content[e]	Gross weight	TiO_2 content[e]	Gross weight	TiO_2 content[e]
1972	786,384	461,422	264,095	187,608	242,758	232,231
1973	807,733	479,231	281,791	199,287	276,907	263,365
1974	851,977	501,276	257,125	182,257	292,661	277,720
1975:						
Alloys and carbide	(2)	(2)	(3)	(3)	(2)	(2)
Pigments	737,209	424,302	147,965	104,585	191,750	181,128
Welding-rod coatings and fluxes	(2)	(2)	--	--	[r]10,319	[r]9,782
Miscellaneous[4]	10,612	8,107	--	--	29,361	28,013
Total	747,821	432,409	147,965	104,585	[r]231,430	[r]218,923
1976:						
Alloys and carbide	(2)	(2)	(3)	(3)	(2)	(2)
Pigments	811,975	490,845	203,964	144,506	207,440	194,950
Welding-rod coatings and fluxes	(2)	(2)	--	--	8,153	7,736
Miscellaneous[4]	10,284	7,168	--	--	22,125	20,926
Total	822,259	498,013	203,964	144,506	237,718	223,612

[e]Estimate.
[1]Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2]Included with "Miscellaneous" to avoid disclosing individual company confidential data.
[3]Included with "Pigments" to avoid disclosing individual company confidential data.
[4]Includes ceramics, chemicals, glass fibers, and titanium metal.

averted by increased imports from NL's European and Canadian subsidiaries and by increased production rates in the rest of the industry. Excluding NL, the industry's operating rate was estimated at close to 85%.

Ferrotitanium.—The amount of ferrotitanium and titanium metal scrap used in steelmaking increased 38% from 2,759 tons in 1975 to 3,802 tons in 1976. The use of these materials in stainless and heat-resisting steels increased 80% to 2,008 tons. Most of this increase was caused by larger amounts of titanium being used in steels for automobile mufflers built to accommodate catalytic convertors.

Ferrotitanium is the main form in which titanium is added to steel or other alloys; however, scrap titanium is used to make some of the ferrotitanium and for direct additions to the alloy melt. The following table shows the amount of ferrotitanium plus titanium scrap used for steel and other alloys in 1973 through 1976. Ferrotitanium is used in 30%, 40%, or 70% titanium grades; information on the amount of each grade used is not available.

Table 6.—Distribution of titanium-pigment shipments, by industry

(Percent)

Industry	1972	1973	1974	1975	1976
Distribution by gross weight:					
Paints, varnishes, lacquers	53.0	52.7	52.6	58.8	51.1
Paper	20.4	19.6	18.5	18.8	21.4
Plastics (except floor covering and vinyl-coated fabrics and textiles)	7.7	9.8	11.3	7.4	10.6
Rubber	3.6	3.2	2.7	2.8	2.7
Ceramics	2.3	2.5	2.1	1.9	1.8
Other	11.8	9.9	8.9	7.7	9.5
Exports	1.2	2.3	3.9	2.6	2.9
Total	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:					
Paints, varnishes, lacquers	52.0	52.5	52.5	58.7	51.1
Paper	20.9	19.8	18.7	19.0	21.4
Plastics (except floor covering and vinyl-coated fabrics and textiles)	7.9	9.8	11.3	7.4	10.6
Rubber	3.7	3.2	2.7	2.8	2.7
Ceramics	2.4	2.6	2.1	1.9	1.9
Other	11.9	9.8	8.8	7.6	9.4
Exports	1.2	2.3	3.9	2.6	2.9
Total	100.0	100.0	100.0	100.0	100.0

Table 7.—Consumption of titanium products[1] in steel and other alloys

(Short tons)

	1973	1974	1975	1976
Carbon steel	981	1,065	804	976
Stainless and heat-resisting steel	970	2,386	1,117	2,008
Other alloy steel (includes HSLA)	1,153	969	838	818
Tool steel	W	W	W	W
Total steel[2]	3,104	4,420	2,759	3,802
Cast irons	124	108	96	100
Superalloys	583	779	585	455
Alloys, other than above	1,166	2,080	1,548	768
Miscellaneous and unspecified	142	34	182	273
Total consumption	5,119	7,421	5,170	5,398

W Withheld to avoid disclosing individual company confidential data; included in "Miscellaneous and unspecified."

[1]Includes ferrotitanium containing 30% to 70% titanium and titanium metal scrap.

[2]Except for data withheld and for unspecified included under "Miscellaneous and unspecified."

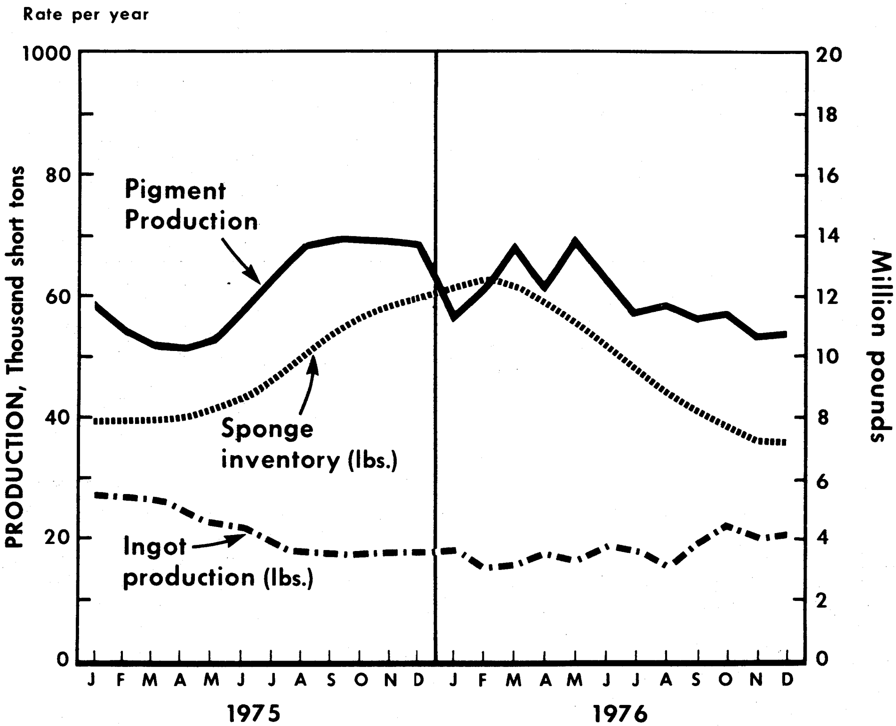

Figure 1.—Salient trends of titanium products, 1975-76.

STOCKS

During 1976, inventories of ilmenite, titanium slag, and rutile increased 11%, 13%, and 9%, respectively. Stocks of titanium sponge increased in the first quarter of 1976, then decreased for the rest of the year, and at yearend were 36% below the December 1975 level. Scrap inventories decreased 6% during 1976. Industry stocks of various grades of titanium pigment were 71,556 tons at the end of 1976, down 17% from the corresponding 1975 figure.

Table 8.—Stocks of titanium concentrates in the United States, December 31

(Short tons)

	Gross weight	TiO_2 content[e]
Ilmenite:		
1974	572,597	325,918
1975	636,881	378,181
1976	707,398	429,801
Titanium slag:		
1974	57,932	40,836
1975	87,683	62,130
1976	99,108	70,242
Rutile:		
1974	107,821	101,394
1975	139,572	131,742
1976	152,251	143,243

[e]Estimate.

PRICES

Concentrates.—Price quotations for ilmenite (imported, 54% TiO_2) in domestic markets remained at $55 per long ton throughout the year. Australian ilmenite prices remained at $A15 to $A18 per metric ton f.o.b. Australian ports. Indian concentrates (58% to 60% TiO_2) were steady at $23 per long ton f.o.b. Indian ports.

Rutile spot prices bulk, f.o.b. cars at Atlantic, Gulf, and Great Lakes ports were quoted at $710 per ton in January and at $510 in February and for the remainder of the year. Long-term contracts presumably were concluded at somewhat lower figures. Published prices f.o.b. Australian ports began the year at $A240 to $A250 per metric ton, decreasing to $A230 to $A235 in the third quarter. Declared valuations of shipments entering U.S. ports were in the range of $138 to $551 per short ton in January and $128 to $276 per short ton in December 1976. Declared valuations of synthetic rutile shipments entering U.S. ports averaged $150 per short ton for the year, and c.i.f. value averaged $190 per short ton.

Titanium slag f.o.b. Sorel, Quebec, increased to $90 per long ton on January 1, 1976, and remained at that level throughout the year.

Metal.—Domestic titanium sponge was quoted at $2.70 to $2.75 per pound throughout the year. Published prices for Japanese sponge were $2.65 to $2.70 per pound early in the year, but dropped in June to $2.45 to $2.50 per pound and remained there for the rest of the year. Quotations for mill products throughout the year were as follows: Bar, $7.48; billet, $4.86; plate, $6.50; and sheet and strip, $11.90 per pound.

Pigment.—The price of titanium dioxide pigment in carload lots increased during the first half of 1976 to 46.5 cents per pound for rutile and 41 cents per pound for anatase, and remained at these levels for the rest of the year.

FOREIGN TRADE

Titanium dioxide exports in 1976 amounted to 20,580 tons, 30% above the 1975 total. Of the 1976 total, Canada received 18%, Venezuela 16%, Brazil 12%, other Latin American and West Indian countries 15%, Western Europe 12%, Republic of Korea 11%, Japan 7%, other Far Eastern nations 6%, and other countries 3%.

Exports of unwrought, waste, and scrap titanium were 42% higher than in 1975; 51% went to the United Kingdom, 23% to Belgium, 11% to Italy, and 4% to Spain. The average valuation was 70 cents per pound, 18 cents per pound less than in 1975. Exports of intermediate mill shapes and mill products were 44% lower than in the previous year.

Imports of ilmenite from Australia in 1976 were 71% greater than in 1975. Imports of Sorelslag were 19% less than in 1975. Imports of natural rutile were 18% higher and imports of synthetic rutile were 48% higher than in 1975.

Imports of unwrought, waste, and scrap titanium were 28% less than those of 1975. Of the 1976 total, 1,778 tons was sponge, which came from Japan (1,360 tons), the U.S.S.R. (256 tons), and the United Kingdom (162 tons). The sponge shipments from Japan, the U.S.S.R., and the United Kingdom had an average declared valuation of $2.01, $1.78, and $1.91 per pound, respectively.

Imports of pigment totaled 68,497 tons during the year and constituted 9.6% of domestic consumption.

Table 9.—U.S. exports of titanium products, by class

Year	Ores and concentrates		Metal and alloy sponge and scrap		Intermediate mill shapes and mill products, n.e.c.		Pigments and oxides	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	3,264	$727	4,730	$9,288	1,719	$19,600	[1]30,379	[1]$24,575
1975	3,147	505	4,326	7,630	1,900	24,726	15,807	12,110
1976	4,802	477	6,144	8,547	1,065	15,039	20,580	16,229

[1]Data adjusted by the Bureau of Mines, U.S. Department of the Interior.

Table 10.—U.S. imports for consumption of titanium concentrates, by country[1]

Country	1974 Quantity (short tons)	1974 Value (thousands)	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Ilmenite:						
Australia	64,506	$1,176	98,352	$1,674	168,402	$2,646
Canada	305	12	221	11	--	--
India	[2]17,637	260	19,428	317	--	--
Sri Lanka	--	--	4,010	57	--	--
Total	82,448	1,448	[3]122,010	2,059	168,402	2,646
Titanium slag[4]	236,272	12,267	212,682	13,844	171,624	13,291
Rutile, natural:						
Australia	189,622	31,758	166,298	35,494	196,035	42,037
Canada[5]	586	277	135	58	--	--
India	4,409	827	--	--	--	--
Total	194,617	32,862	166,433	35,552	196,035	42,037
Rutile, synthetic:						
Australia[1]	14,454	1,851	34,222	6,218	43,866	6,955
India	10,976	1,348	6,614	900	11,011	1,668
Japan	26,442	2,712	16,878	3,599	26,363	3,193
Taiwan	--	--	353	92	4,437	996
Total	51,872	5,911	[3]58,066	[3]10,810	85,677	12,812
Titaniferous iron ore:[6] Canada	201,256	2,373	46,031	1,255	91,692	2,778

[1]Data adjusted by the Bureau of Mines.
[2]May have been used in heavy aggregate.
[3]Data do not add to total shown because of independent rounding.
[4]All from Canada.
[5]Country of transshipment rather than country of production.
[6]Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel furnace flux.

Table 11.—U.S. imports for consumption of unwrought titanium and waste and scrap

Country	1974 Quantity (short tons)	1974 Value (thousands)	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Australia	--	--	3	$5	--	--
Austria	1,299	$874	--	--	--	--
Belgium-Luxembourg	14	8	--	--	28	$24
Canada	142	194	154	230	219	291
France	79	149	41	92	29	49
Germany, West	247	556	69	185	153	317
Japan	2,797	6,510	2,545	9,882	1,659	6,114
Mexico	5	3	3	3	3	8
Netherlands	--	--	18	31	152	145
South Africa, Republic of	--	--	--	--	2	4
Spain	--	--	--	--	7	26
Sweden	244	211	4	11	61	57
U.S.S.R	4,032	7,410	1,698	4,326	742	1,289
United Kingdom	979	1,972	531	1,346	583	1,428
Total	9,838	17,887	5,066	16,111	3,638	9,752

WORLD REVIEW

Australia.—Australia continued to dominate world markets in mineral sands, particularly ilmenite, rutile, and zircon. In 1976, ilmenite production was 1,104,300 short tons including an estimated 18,740 short tons of leucoxene, about the same as in 1975. Rutile production was 435,791 tons, 15% higher than in 1975. Exports of ilmenite were 1,063,373 tons, up 77% from those of 1975, and rutile exports were 382,346 tons, 9% higher than in 1975. Ilmenite exports went mainly to the United States,

Table 12.—Titanium: World production of concentrates (ilmenite, rutile, and titaniferous slag), by country

(Short tons)

Country[1]	1974	1975	1976[p]
Ilmenite: [2]			
Australia[3]	[r]916,602	1,135,379	[e]1,104,300
Brazil	7,433	5,066	[e]5,100
Finland	167,551	135,143	135,143
India[e]	[r]146,000	90,000	90,000
Korea, Republic of	176	--	--
Malaysia[4]	169,238	123,732	198,410
Norway	934,911	580,549	845,270
Portugal	302	234	405
Sri Lanka	[r]93,856	70,559	61,524
United States[5]	744,571	717,281	652,404
U.S.S.R[e]	338,000	360,000	419,000
Total	[r]3,518,640	3,217,943	3,511,556
Rutile:			
Australia	351,308	379,233	435,791
Brazil	161	115	[e]116
India[e]	[r]6,400	4,000	4,000
Sri Lanka	[r]3,450	3,427	1,146
United States	6,446	W	W
U.S.S.R.[e]	30,000	30,000	30,000
Total	[r]397,765	[6]416,775	[6]471,053
Titaniferous slag:			
Canada[7]	931,168	826,564	907,200
Japan	4,855	4,942	3,843
Total	936,023	831,506	911,043

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]In addition to the countries listed, the Republic of South Africa may also produce titanium concentrates, but available information is inadequate to make reliable estimates of output levels.
[2]Ilmenite is also produced in Canada and reported separately in Canadian sources but is not included here because it is almost entirely used in slag production (see titaniferous slag).
[3]Includes leucoxene as follows in short tons: 1974—16,924; 1975—18,629; 1976—[e]18,740.
[4]Exports.
[5]Includes a mixed product containing ilmenite, leucoxene, and rutile.
[6]Does not contain U.S. production in order to avoid disclosing individual company confidential data.
[7]Contains 70% to 72% TiO_2.

the United Kingdom, Japan, France, and Brazil, with rutile going mostly to the United States, the United Kingdom, the Netherlands, Japan, and West Germany.

Beach sand minerals supply was reportedly exceeding demand as producers were completing expansion plans started during high price periods in 1973-74. Also contributing to the outlook for a continued oversupply situation was the imminent addition of new capacity elsewhere, as at Richards Bay, Republic of South Africa, and in Sierra Leone. Factors tending to decrease supply were the shrinking reserves on the east coast of Australia and some reduction of rutile production there for environmental reasons.

Early in 1976 the Australian Government sharply reduced the minimum permissible export price for mineral sand concentrates. Late in the year, the Australian Government issued an order withdrawing all export licenses for mineral concentrates extracted from Fraser Island, Queensland, sands effective December 31, 1976. Prime Minister Malcolm Fraser said that this decision was taken to protect the environment of Fraser Island, the largest sand island in the world, following recommendations from a special environmental commission. Fraser Island was described by the commission as being of international environmental significance, with beach sand mining producing permanent and irreversible environmental harm.

Two companies were affected by the Fraser Island action: Queensland Titanium Mines Pty., Ltd. (owned by NL Industries subsidiaries) and D. M. Minerals, Ltd. (a partnership between Dillingham Construction Pty., Ltd., and Murphyores Inc. Pty., Ltd.) Their operations on Fraser Island were said to represent about 14% of Australia's installed productive capacity for rutile. Reserves on the island were placed at 874,000 tons of rutile, 917,000 tons of zircon, and smaller quantities of ilmenite and monazite. The Environmental Minister of Australia stated that compensation for the mining companies involved would be considered.

Mineral Deposits, Ltd., was considering development of a sand deposit at Agnes Water, 80 miles south of Gladstone, Queensland. Cost to bring the project into production was estimated at $A14 million, with annual production of 132,000 tons of ilmenite and 22,000 tons of rutile, over a 10-year period.

Western Titanium Ltd.'s mineral sands mining and concentrating complex near Eneabba, Western Australia, was completed, and shipments of concentrates were to start in October. The cost of the plant, port installation, and housing was estimated at $A18.5 million. A merger was announced between Western Titanium and Associated Minerals Consolidated, Ltd., both members of the Consolidated Gold Fields Australia Ltd. group. With Western Titanium's Eneabba operations expected to be in full production during 1977, the combined companies were expected to have an annual production capacity of 440,000 to 550,000 tons of ilmenite, 143,000 of tons rutile, 50,000 tons of beneficiated ilmenite, and 187,000 tons of zircon.

Westralian Sands was expanding its operations at Yoganup, Western Australia, to increase ilmenite capacity to 550,000 metric tons per year. Instead of rutile and leucoxene, production was to include 55,000 tons per year of "HYTI 93" (minimum 93% TiO_2) and "HYTI 68" (minimum 68% TiO_2). The full increase in ilmenite production was to await construction of a proposed plant that would produce 110,000 tons per year of synthetic rutile from ilmenite.

Western Mining Corp. purchased the Jurien Bay project, near the end of 1975, not far from the Eneabba area, from Black Sands Pty. Ltd. for about $A13 million; in early 1976 it was building toward full production planned at 33,000 tons per year of rutile and 33,000 tons per year of zircon. The company's reserves at Jurien were stated as 3.5 million tons of heavy minerals, with comparable additional reserves at nearby partially explored Cooljarloo.

Alliance Oil Development Australia NL and Metals Exploration Ltd. announced the discovery of mineral sands deposits at Cataby, 93 miles north of Perth. Drilling so far has indicated the presence of about 770,000 tons of heavy minerals in 10 million tons of sand. The heavy minerals consist of about 70% ilmenite, 7% rutile, 12% zircon, and 1.5% monazite.

Brazil.—The New Jersey Zinc Co. made an agreement with Mineração Vale do Paranaiba, South America, (VALEP) and Cia. Vale do Rio Doce (CVRD) to develop a process for producing upgraded ilmenite and titanium dioxide from complex ores containing anatase. Estimates of reserves have ranged from 132 million tons of ore averaging 21.6% TiO_2 up to 1,600 million tons of ore containing 10% TiO_2, near Tapira and Salitre, Minas Gerais. The ore occurs in carbonatite rocks containing the primary titanium minerals perovskite, ilmenite, magnetite, and rarely rutile, associated with apatite and pyrochlore. The bulk of the titanium reserves are anatase and leucoxene, weathering products of the primary minerals. Plans were being made to recover phosphate, columbium, rare-earth elements, and titanium. Production was scheduled to start in May 1978.

Nearly 94 million tons of titanium ore reportedly have been discovered near Campo Alegre de Lourdes, 500 miles northwest of Salvador, Bahia. The deposits were reported to contain 20.6 million tons of TiO_2 in the form of ilmenite.

Titanium Fabrication Corp. (Ti-Fab) of Fairfield, N.J., was reported to be setting up a fabrication and service organization to make titanium metal products in Brazil to satisfy what the company referred to as a substantial market in that country. A long range goal was to establish a primary titanium metal extraction facility in Brazil, utilizing Brazilian ore sources and employing electrolytic processing rather than the Kroll process for reduction to metal.

Canada.—Demand for Quebec Iron and Titanium Corp. (QIT) Sorelslag was above production capacity in 1976 when QIT produced 907,193 tons of Sorelslag (70% to 72% TiO_2); 604,796 tons of Sorelmetal (a low manganese pig iron); and 156,799 tons of Sorelflux (ilmenite ore used as a flux in electric steel furnaces). Although demand for Sorelslag has been increasing, inventories of Sorelmetal had built up to 425,598 tons by September 1976, and recovery in demand for this coproduct was very slow.

Most of the Sorelslag was exported to the United Kingdom, Western Europe, and the United States, with about 13% sold to the two Canadian producers of pigments: Canadian Titanium Pigments, Ltd., Varennes, Quebec, a subsidiary of NL Industries, and Tioxide of Canada Ltd., Tracy, Quebec, a subsidiary of BTP Tioxide, Ltd., United Kingdom. The combined capacities of the two Canadian producers, both of which use the sulfate process, total about 76,000 tons per year.

An agreement was made between Laurentian Titanium Mines and Inco Limited for Inco to provide funds for exploration of

Laurentian's titaniferous magnetite deposit about 47 miles northeast of Montreal. Inco could eventually become the owner of the deposit, which has estimated reserves of 124 million tons of titaniferous magnetite and 16 million tons of ilmenite.

European Economic Community (EEC).—Common Market ministers reportedly postponed until 1977 proposals for standards to regulate the disposal of wastes from titanium dioxide plants. The ministers failed to agree on a single set of disposal standards that would have required 90% reduction of these wastes by 1985. Instead, they appeared to prefer a British proposal that producers be allowed to continue ocean discharge to the extent that plant wastes can be absorbed by the surrounding environment.

Germany, West.—Du Pont reportedly gave up its 26% ownership of Pigment Chemie, with Metallgesellschaft gaining control of the company. Pigment Chemie operates a 55,000-ton-per-year titanium dioxide pigment plant at Duisberg.

Italy.—Montedison, S.p.A., announced plans to phase out the older of its two plants at Spinetta Marengo, southwest of Milan, since treatment and waste disposal costs did not permit profitable operation. The company plans to build a chloride process facility at Crotone in Calabria, with production planned for 1979. Montedison is said to be subject to the most stringent pollution controls in Europe, and the Italian Government has supported Montedison in its efforts to persuade the EEC commission that all European titanium dioxide producers should be governed by the same effluent controls.

Society Mineraria Italiana confirmed discovery of a deposit of rutile in Savona with reserves of 31 million tons of ore containing 6% TiO_2. Open pit mining was planned at a rate of 1 million tons ore per year, using a patented upgrading process to yield 20,000 tons per year of concentrate containing 95% TiO_2.

Norway.—Producton of ilmenite concentrate in 1976 was 845,244 tons.

Spain.—Titanio S.A. reportedly started up a 50,000-ton-per-year pigment plant at Huelva, using Tioxide International's sulfate process technology. Titanio is owned 55% by Esplosivos Rio Tinto S.A. and 45% by Tioxide Group, Ltd. The plant was said to be using both the sulfate and chloride pigment processes.

United Kingdom.—The Tioxide Group, Ltd., was planning extensive improvements and modifications of the BTP Tioxide, Ltd., chloride process plant at Teeside, England, including replacing original chlorination units with a newly developed chlorination plant and installating of the most recent design of vapor-phase oxidation equipment in place of the existing units.

The Tioxide Group reported a marked improvement in sales and profits during the first half of 1976, compared with the depressed levels of 1975. Capacity utilization was considerably above the 60% level average for 1975.

Wogen Resources started a new company, Wogen Titanium Ltd., which began construction of a 3,000- to 3,500-ton-per-year ferrotitanium plant. Production was expected to begin in the first half of 1977.

Imperial Metal Industries Ltd. (IMI), Britain's only titanium mill products producer, began a campaign in August 1976 against what it called unfair competition in the international titanium market. In complaints to the EEC and the United Kingdom Government, IMI claimed that Japanese titanium was flooding the United Kingdom market at prices as much as 55% below the Japanese domestic prices. It also stated that the EEC common external tariff of 6% to 8% was hurting its business since United States and Japanese import tariffs were 18% and 12%, respectively. In November 1976, there were similar complaints about price cutting by the Soviet Union.

India.—Ilmenite deposits reportedly have been found in seabed sediments around Ratnagiri in Maharashtra State by the National Institute of Oceanography. The deposits may contain several million tons of ilmenite.

Work on a titanium dioxide pigment complex for the State of Kerala was scheduled to begin early in 1977. Plans were for a production rate of 24,000 tons per year, starting in 1980, with expansion later to about 100,000 tons per year. Total cost of the project, to be located near Quilon, is estimated at about $90 to $110 million, with the first stage costing about $55 million.

Japan.—Toho Titanium Co., Ltd., and Osaka Titanium Co., Ltd., produced 6,996 tons of sponge metal in 1976, a decrease of 16% from 1975 production. Exports of sponge and fabricated products in 1976 were 1,799 tons and 963 tons, respectively; the United States received 75% of the sponge; while the Netherlands, West Germany

France, and the United Kingdom received over 24%. Domestic sales and internal plant consumption increased 16% to 4,755 tons.

Three Mitsubishi-group companies made a contract for a 1-year option on the use of Du Pont technology for chlorinating higher grade concentrates. Formal licensing was not yet effected but seemed probable. Mitsubishi Metal and Mitsubishi Chemical are believed to have developed a new form of synthetic rutile. The third company, Asahi Glass, is a large producer of chlorine. These and other factors suggest that the companies were seriously considering a new large scale chloride process project, aimed at replacing existing sulfate plants that have pressing pollution problems.

Malagasy.—Montedison of Italy completed exploration and test work directed toward exploiting ilmenite deposits near Tamatave on the east coast of Madagascar. Montedison announced its acceptance of 51% State ownership of the proposed ilmenite mining venture. Montedison was reportedly proceeding with plans for a plant to produce 200,000 tons per year of ilmenite and 28,000 tons of zircon.

Malaysia.—Malaysian Titanium Corp. began operation of a synthetic rutile plant at Ipoh, with expected production of 4,000 tons in 1976, 50,000 tons in 1977, and capacity production of 100,000 tons in 1980. Malaysian Titanium Corp. is a joint venture of Straits Trading Co., Ltd., Pernas Mining, Empat Nombor Ekor, Malaysian Tin Smelting, and Benilite Corp. of America. Raw material used is ilmenite in tin tailings from the area around tin mines in Lahat, 4.5 miles from Ipoh.

New Zealand.—New Zealand Steel Mining Co. was reported to have offered to sell an additional 1 to 1.5 million tons per year of titaniferous ironsand to Japanese steel firms starting in 1977 in addition to fulfilling an existing contract for 1.3 million tons per year from the Taharoa sand mines. Waipipi Iron Sands Ltd. was also a major producer at Waipipi.

Titanomagnetite ores in New Zealand also provide the basis for a local steel industry, utilizing the a solid fuel direct-reduction process.

Sierra Leone.—It was reported by Bethlehem Steel Corp. and Nord Resources that the Export-Import Bank agreed to lend an additional $9 million to finance their rutile mining venture in Sierra Leone. Bethelehem holds an 85% interest in Sierra Rutile Ltd., with Nord holding 15%. It had been estimated that the cost of the project would be about $28 million. Initial production of rutile was still planned for late 1978 with an eventual annual rate of about 100,000 tons of concentrate from a deposit containing about 3 million tons of rutile.

South Africa, Republic of.—Development of the titanium deposit at Richards Bay in Natal was proceeding on schedule. Mining was expected to begin in late 1977 with smelting to start in early 1978. The planned annual production rate was about 440,000 tons of 85% TiO_2 slag, 62,000 tons of rutile, 127,000 tons of zircon, and 239,000 tons of low-manganese pig iron. About 1 million tons per year of ilmenite was to be produced and smelted in electric furnaces to make the high-TiO_2 slag using Quebec Iron and Titanium Corp. technology. The ore occurs in dune deposits estimated to contain over 770 million tons of heavy-mineral-bearing sand.

Because of its high TiO_2 content and low magnesium content, the Richards Bay (RB) slag will be competitive for use in the chloride pigment process as well as the sulfate process. Japan's five titanium pigment producers were reported to have concluded a long-term agreement to import RB slag at an annual rate between 70,000 and 100,000 tons. Partners in the $320-million Richards Bay project include Quebec Iron and Titanium Corp. (40%), Union Corp. (project manager with 30% interest), Industrial Development Corp. of South Africa (20%), and the South African Mutual Life Assurance Society (10%).

Tanzania.—It was reported that titanium deposits have been found near Mtwara on the southeast Tanzanian coast and that feasibility studies on exploiting the deposits had begun.

U.S.S.R.—The Soviet Union was reportedly planning to exploit rich reserves of titanium ore found in the Yaregsk region of the northern Ural Mountains. The reserves are said to be extensive and higher in grade than any previously found in the U.S.S.R. Beneficiation methods were being investigated.

Production of titanium metal in the U.S.S.R. was estimated at 35,000 tons, 7% higher than in 1975. Development of the titanium industry continued to be based mainly on Ukranian and Siberian ilmenite and rutile. Reports indicated that a titaniferous slag containing 83% TiO_2 was being produced at the Zaporozhye plant in the Ukraine. Production of titanium was planned to be 39,000 tons in 1977 and 46,000 tons in 1980, with exports of titanium sponge to be increased significantly.

The Soviet Union reportedly was planning to build a 110,000-ton-per-year titanium dioxide plant at Armansk, using the sulfate process, at a cost of about $170 million. Armansk is the site of an existing 30,000-ton-per-year TiO_2 plant built using technology supplied by Montedison. Possible sources of technology said to be under consideration by the Soviet Union include American Cyanamid, Du Pont, and Kronos Titan in West Germany.

TECHNOLOGY

The U.S. Geological Survey published a series of papers on the geology and resources of titanium, covering titanium partitioning in rocks, source rocks of titanium placer deposits, the types of deposits associated with various rocks, and describing some alluvial ilmenite placer deposits in central Virginia.[4] A separate publication reported on heavy mineral resources in the Port Leyden area of New York State.[5]

A review of ore dressing investigations on Canadian titaniferous ores was published.[6] Aside from the Allard Lake area in Quebec, deposits with the best potential include the 140-million-ton magnetite-ilmenite deposit in the Temagami area of Ontario, containing 38.5% Fe and 18.7% TiO_2, with combined concentrates assaying about 48% Fe and 21.5% TiO_2. Less well-known deposits in the Lanark and Leeds areas of Ontario yield magnetite concentrates containing about 0.24% TiO_2 and might be exploitable if the present specification of 0.1% TiO_2 in iron concentrate is increased to 0.3% TiO_2.

At the Third International Conference on Titanium held in Moscow in May 1976, emphasis was on improving properties in existing alloys such as fracture toughness, fatigue, and notch strength as opposed to developing new alloys with higher tensile strength. There were papers on processing techniques that make more efficient use of titanium such as casting, forging, superplasticity, and powder metallurgy. It was disclosed that the Soviet titanium industry uses hard rock ilmenite as a basic feed material, smelting it to obtain a slag for chlorination containing 88% to 90% TiO_2. Japanese titanium producers were reportedly using combinations of rutile and sand ilmenite (converted to synthetic rutile), or rutile and titanium slag. In the United States, nearly all the feed material for titanium metal manufacture was Australian rutile. All titanium-producing countries except the Soviet Union were showing increasing consumption of titanium for commercial applications such as utility surface condensers, reaction vessels, and dimensionally stable anodes.

In the United States, research is continuing to determine the range of thermomechanical variables under which titanium alloys can be processed to achieve maximum material utilization with satisfactory product properties. Procedures being investigated include hot die-forging processes,[7] impact forming, diffusion bonding,[8] and superplastic forming, all of which are cost cutting alternatives to machining.[9]

A titanium scrap reclamation process used by Teledyne Allvac was selected by the Air Force Materials Laboratory as the only reliable way to recycle aerospace machine shop chips and turnings. The problem of removing particles of tungsten carbide cutting tools was solved by melting the scrap metal using a rotating nonconsumable copper electrode. The rotating electrode avoids tip erosion, and the cutting tool fragments settle to the bottom of the furnace allowing the molten titanium to be poured off to form either a consumable electrode or a remelt ingot.[10]

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[4]U.S. Geological Survey. Geology and Resources of Titanium. U.S. Geol. Survey Prof. Paper 959-A through H, 1976, pp. A1-H15.

[5]Force, E. R., B. R. Lipin, and R. E. Smith. Map Showing Heavy Mineral Resources in Pleistocene Sand of the Port Leyden Quadrangle, Southwestern Adirondack Mountains, New York. U.S. Geological Survey, Map MF-728B, 1976.

[6]Raicevic, D. Technical Review of Ore Dressing Investigations on Canadian Titaniferous Ores Conducted at CANMET From 1950 to 1975. CANMET Rept. 76-34. Department of Energy, Mines and Resources, Ottawa, Canada. 97 pp.

[7]American Metal Market. Titanium Forgings Getting Critical Eye From Designers. V. 83, No. 46, Mar. 8, 1976, p. 30.

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Papers were published describing the BCA Cyclic Process[11] and the Ishihara process[12] for making a rutile substitute from ilmenite. Both processes are being utilized commercially.

Bureau of Mines research related to titanium included studies on methods of recovering titanium from ilmenite[13], recovery of chlorine and iron oxide from ferric chloride[14], soda ash smelting-leaching procedure for preparing sodium titanate from domestic ilmenite[15], electrodeposition of titanium boride coatings on various metals[16], reflectance and emittance of thin film absorber stacks containing zirconium or titanium compound thin films[17], the use of titanium carbide as a deoxidizer in electric furnace steelmaking[18], and a process for chlorination of titanium bearing materials and for dechlorination of iron chloride[19]. A patent was obtained on a process for production of synthetic rutile from slag[20].

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Tungsten

By Ben A. Kornhauser[1]

Domestic production increased 4% over that of 1975, and consumption rose 15%. Production and consumption in 1976 were 5.8 and 16.1 million pounds of contained tungsten, respectively. Essentially all domestic production came from two mining operations, one in California and one in Colorado. Production of ammonium paratungstate (APT) increased 25%, and production of tungsten products rose 44%; consumption of APT increased 54%, and consumption of tungsten products rose 30%. Imports for consumption of tungsten in concentrate decreased 19% to 5.3 million pounds, while exports of tungsten concentrate increased 31% to 1.7 million pounds of contained tungsten.

The reported unit value of tungsten concentrate shipments in 1976, f.o.b. domestic mines and custom mills, increased 20% when compared with that of 1975, and averaged $100 per short ton unit.

Legislation and Government Programs.—The Office of Stockpile Disposal, General Services Administration (GSA) continued to sell excess stockpiled tungsten

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Table 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Concentrate:					
Mine production	8,150	7,575	7,381	5,588	5,830
Mine shipments	7,045	7,059	7,836	5,490	5,869
Value	$18,104	$19,154	$37,413	$29,090	$37,266
Consumption	14,107	15,386	16,298	14,012	16,107
Releases from Government stocks	3	1,498	6,071	4,135	3,708
Exports[1]	95	90	1,187	1,316	1,729
Imports, general	5,898	11,047	11,786	6,908	5,802
Imports for consumption	5,739	10,834	11,096	6,570	5,301
Stocks, Dec. 31:					
Producers	1,966	225	529	531	150
Consumers	2,229	1,446	1,565	1,958	1,002
Employment[2]	510	535	540	525	540
Ammonium paratungstate:					
Production	([3])	13,012	14,707	10,282	12,808
Consumption	([3])	13,945	15,733	10,353	15,921
Stocks, Dec. 31: Producers and consumers	([3])	945	1,062	1,704	1,438
Primary products:					
Production	14,090	16,600	20,131	12,634	18,226
Consumption	13,296	17,984	20,556	12,934	16,799
Stocks, Dec. 31:					
Producers	4,680	3,523	3,628	3,976	3,390
Consumers	2,121	2,051	2,771	2,753	2,778
World: Concentrate:					
Production	84,952	83,612	[r]82,832	[r]84,262	91,845
Consumption	76,583	84,857	[r]83,506	[r]73,557	80,962

[r]Revised.
[1]Estimated tungsten content.
[2]Estimated number of employees at mines and mills, excluding office workers, at yearend.
[3]Included with primary products.

concentrate on the basis of monthly sealed bids. The excess concentrate was offered on a regular monthly basis at the disposal rate of 500,000 pounds of contained tungsten, of which 375,000 pounds was for domestic use only and 125,000 pounds was for export only. Occasionally, supplemental offerings also were made. These offerings resulted in concentrate sales of 3,708,407 pounds of contained tungsten, of which 1,844,935 pounds was for domestic use and 1,863,472 pounds was for export. The material released for domestic use was sold at prices, ex-duty, that ranged from $81.74 to $127.07 per short ton unit. Material released for export was sold at prices, ex-duty, that ranged from $78.87 to $127.00 per short ton unit. However, actual deliveries of concentrates for domestic use and export in 1976 were 4,003,767 pounds of contained tungsten.

On October 1, 1976, the material stockpile goals (formerly termed objectives) were revised by the Federal Preparedness Agency of GSA. These goals were to be updated as necessary in the future. U.S. Government tungsten stockpile materials, inventories, and goals are presented in table 2.

Executive Order No. 11888, dated November 24, 1975, modified the Tariff Schedules of the United States to implement the Generalized System of Preferences (GSP) authorized by Title V of the Trade Act of 1974. The Executive order designated beneficiary countries and eligible articles for the GSP. Since the implementation of GSP, it has been modified by various Executive orders. Products that are eligible articles and meet the conditions stipulated in the act are duty-free, if imported into the United States directly from a beneficiary country on or after January 1, 1976. Countries eligible under section 504 (c) of the Trade Act to export tungsten ores and concentrates to the United States, duty-free, are noted in table 13. Withdrawal of GSP eligibility from a country for duty-free treatment would occur if the GSP beneficiary country, in any one year, exported more than $29.9 million of tungsten or more than 50% of the total U.S. tungsten imports. The program will expire on January 4, 1985.

Table 2.—U.S. Government tungsten stockpile materials, inventories, and goals

(Thousand pounds of contained tungsten)

Material	Goals[1]	Inventory by program, Dec. 31, 1976			
		National stockpile	DPA[2] inventory	Supplemental stockpile	Total[3]
Tungsten concentrate:					
Stockpile grade	8,823	65,494	3,529	3,228	72,251
Nonstockpile grade	--	34,923	421	1,153	36,497
Total[3]	8,823	100,417	3,950	4,381	108,749
Ferrotungsten:					
Stockpile grade	17,769	841	--	--	841
Nonstockpile grade	--	1,185	--	--	1,185
Total[3]	17,769	2,025	--	--	2,025
Tungsten metal powder:[4]					
Stockpile grade	3,290	1,493	--	--	1,493
Nonstockpile grade	--	273	--	--	273
Total[3]	3,290	1,765	--	--	1,765
Tungsten carbide powder:					
Stockpile grade	12,845	842	--	--	842
Nonstockpile grade	--	112	--	1,080	1,191
Total[3]	12,845	953	--	1,080	2,033

[1]Goals established Oct. 1, 1976.
[2]Defense Production Act (DPA).
[3]Data may not add to totals shown because of independent rounding.
[4]Includes hydrogen- and carbon-reduced tungsten metal powder, formerly reported separately.

DOMESTIC PRODUCTION

Domestic mine production of tungsten concentrate increased 4% over that of 1975 and totaled 5.8 million pounds of contained tungsten for the year; mine shipments increased 7% to 5.9 million pounds. Forty-nine mines in 9 Western States reported production, but only 46 mines reported concentrate shipments. However, only two mines essentially operated continuously throughout 1976; these were the Pine Creek mine and mill of the Metals Div., Union Carbide Corp. (UCC), northwest of Bishop, Inyo County, Calif., and the Climax mine and mill of Climax Molybdenum Co., a division of AMAX, Inc., at Climax, Lake County, Colo. The major mineral value recovered at Pine Creek continued to be tungsten, with minor amounts of byproduct molybdenum, copper, gold, and silver. UCC processed ore directly into (APT), an intermediate tungsten product suitable for conversion to tungsten powder.

The major mineral value recovered at Climax was molybdenum. Concentrates of tungsten, tin, and pyrite were recovered as coproducts, which depend upon the rate of molybdenum production. At Climax, the maximum annual production capacity for tungsten concentrate is about 2.5 million pounds of contained tungsten.

Intermittent tungsten concentrate production and/or shipments also were reported from Pima County, Ariz.; Fresno, Inyo, Kern, Los Angeles, Madera, San Bernardino, San Diego, and Tulare Counties, Calif.; Boulder County, Colo.; Custer and Valley Counties, Idaho; Granite County, Mont.; Churchill, Elko, Esmeralda, Nye, Pershing, and White Pine Counties, Nev.; Baker County, Oreg.; Box Elder and Tooele Counties, Utah; and Stevens County, Wash. The Tungsten Queen mine and mill of Ranchers Exploration & Development Corp., near Townsville in Vance County, N.C., remained on standby status for the entire year. UCC development of the Tempiute mine and mill in southern Nevada was delayed, with completion and startup rescheduled for mid-1977. When operating at designed capacity, this facility expects to produce 2 million pounds of tungsten annually, plus a byproduct zinc concentrate. Tempiute will process the scheelite ore to a tungsten semiconcentrate for conversion to APT at UCC's Pine Creek, Calif., facilities. Eighteen mines were considered discontinued in 1976 based on submitted information and unclaimed reporting forms.

Table 3.—Tungsten concentrate shipped from mines in the United States

Year	Quantity			Reported value, f.o.b. mine[1]		
	Short tons 60% WO_3 basis[2]	Short ton units WO_3[3]	Tungsten content (thousand pounds)	Total (thousands)	Average per unit of WO_3	Average per pound of tungsten
1972	7,401	444,145	7,045	$18,104	$40.77	$2.56
1973	7,418	445,051	7,059	19,154	43.04	2.71
1974	8,233	494,012	7,836	37,413	75.73	4.77
1975	5,769	346,112	5,490	29,090	84.05	5.30
1976	6,168	370,069	5,869	37,266	100.70	6.35

[1]Values apply to finished concentrate and are in some instances f.o.b. custom mill.
[2]A short ton of 60% tungsten trioxide (WO_3) contains 951.6 pounds of tungsten.
[3]A short ton unit equals 20 pounds of tungsten trioxide (WO_3) and contains 15.86 pounds of tungsten.

CONSUMPTION AND USES

Reported domestic consumption and stocks of tungsten products, by end use during 1976, are given in table 6. Cutting and wear-resisting materials continued to be the major end use of tungsten, primarily as tungsten carbide (WC). This end use accounted for 68% of total tungsten product consumption, of which 62% was used as WC in cutting and wear-resisting materials and 7% was consumed in hard-facing rods and materials. Total tungsten product consumption increased 30% to 16.8 million pounds of contained tungsten for the year. Other major end-use categories were mill products, 14%; specialty steels (tool, stainless, and alloy), 9%; superalloys, 3%; and chemicals, 4%.

The major consumption distribution of intermediate tungsten products used to make end-use items in 1976 follows: Tungsten carbide (including cemented, crushed and cast, and crystalline), 39%; tungsten metal powder, 41%; ferrotungsten, 6%; and scrap, 9%.

Domestic shipments, imports, consumption, and the average price of tungsten concentrate are presented graphically in figure 1. The production, disposition, and stocks of tungsten products in the United States during 1976 are presented in table 5, and the major domestic companies engaged in tungsten operations during 1976 are listed in table 4.

Figure 2 is a simplified tungsten flow diagram showing the major process flow of intermediate tungsten products and major end-use items involved in the tungsten processing industry.

The use of coated tungsten carbides and other coated materials for cutting tools increased approximately 25% during 1976, according to Bureau of Mines data and as noted by Metcut Research Associates, Cincinnati, Ohio.[2]

[2]American Metal Market. V. 83, No. 165, Aug. 23, 1976, p. 23.

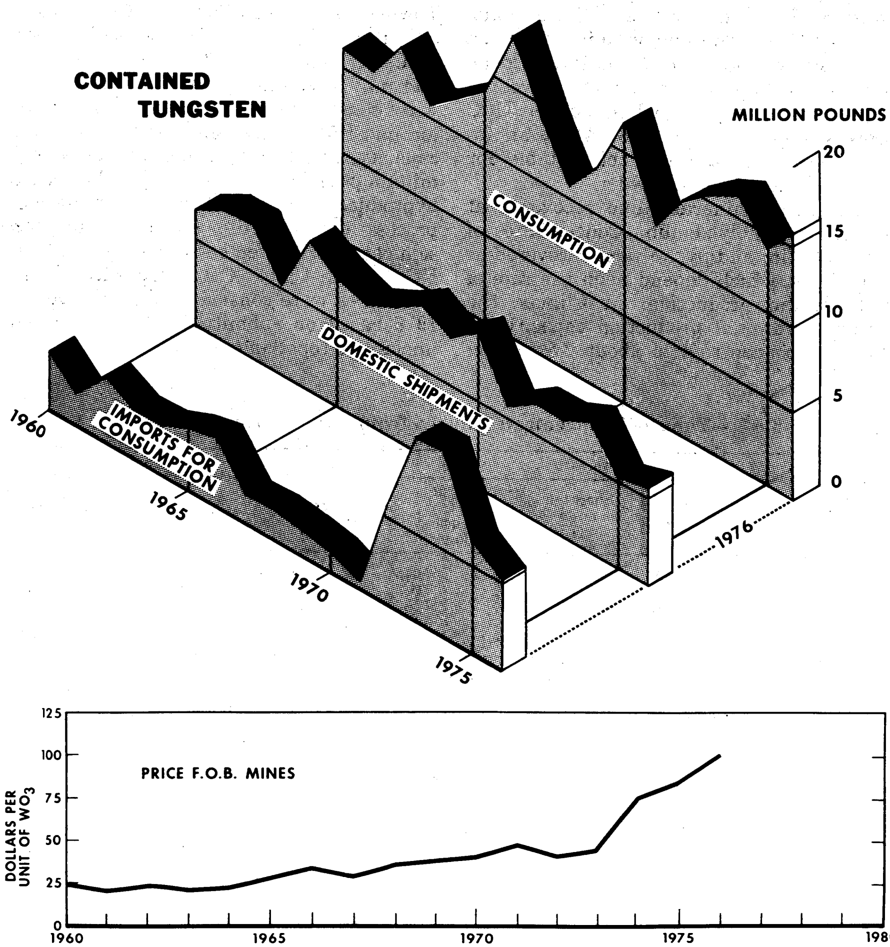

Figure 1.—Domestic shipments, imports, consumption, and average price of tungsten concentrate.

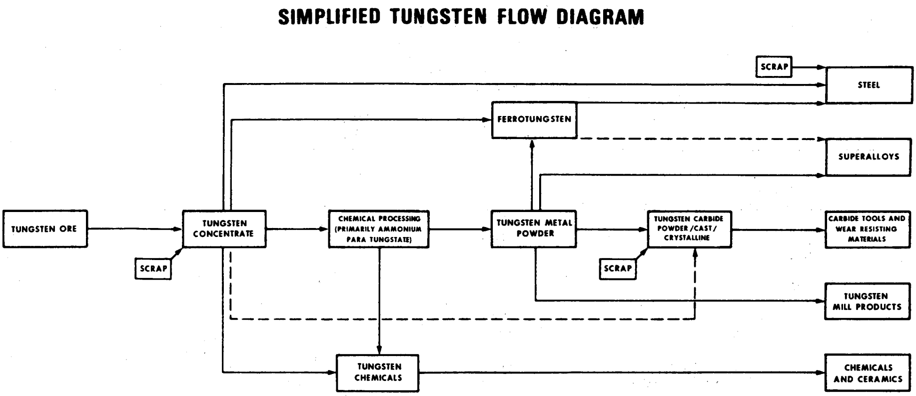

Figure 2.—Simplified tungsten flow diagram.

Table 4.—Major producers of tungsten concentrate and principal tungsten processors in 1976

Company	Location of mine, mill, or processing plant
Producers of tungsten concentrate:	
Abracadabra Exploration Corp	Gold Hill, Utah.
AMAX Inc., Climax Molybdenum Div	Climax, Colo.
Oxbow Tungsten Mine, Inc	Mountain City, Nev.
Union Carbide Corp., Mining & Metals Div.[1]	Bishop, Calif.
Processors of tungsten:[2]	
Adamas Carbide Corp	Kenilworth, N.J.
Fansteel, Inc	North Chicago, Ill.
General Electric Co	Euclid, Ohio; Detroit, Mich.
GTE Sylvania, Inc., a subsidiary of General Telephone & Electronics Corp	Towanda, Pa.
Kennametal, Inc	Latrobe, Pa; Fallon, Nev.
Li Tungsten Corp	Glen Cove, N.Y.
Teledyne Firth Stirling	McKeesport, Pa.
Teledyne Wah Chang Huntsville	Huntsville, Ala.
Union Carbide Corp., Mining & Metals Div	Niagara Falls, N.Y.
Westinghouse Electric Corp	Bloomfield, N.J.

[1]At its Pine Creek mine and mill in California, UCC processes ore "straight through" to APT.
[2]Major consumers of intermediate tungsten products.

Table 5.—Production, disposition, and stocks of tungsten products in the United States

(Thousand pounds of contained tungsten)

	Hydrogen and carbon-reduced metal powder	Tungsten carbide powder: Made from metal powder	Tungsten carbide powder: Crushed and crystalline	Chemicals	Other[1]	Total[2]
1975:						
Gross production during year	9,782	7,022	1,716	3,697	1,108	23,325
Used to make other products listed here	7,167	--	249	3,275	([3])	10,691
Net production	2,615	7,022	1,467	422	1,108	12,634
Disposition:						
To other processors	1,101	226	329	101	834	2,592
To end-use consumers	4,783	5,589	383	319	197	11,272
To make products not listed in this table	723	1,331	1,168	9	--	3,231
Producer stocks, Dec. 31	1,998	707	598	352	322	3,976
1976:						
Gross production during year	15,873	10,054	1,532	5,932	603	33,995
Used to make other products listed here	10,505	--	223	5,040	([3])	15,769
Net production	5,368	10,054	1,309	892	603	18,226
Disposition:						
To other processors	861	272	335	384	489	2,341
To end-use consumers	6,434	8,242	419	553	279	15,927
To make products not listed in this table	2,372	1,913	1,101	14	2	5,402
Producer stocks, Dec. 31	1,881	547	486	365	111	3,390

[1]Includes ferrotungsten, scheelite (produced from scrap), nickel-tungsten, and self-reducing oxide pellets.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.

STOCKS

At yearend 1976 producer-held stocks of tungsten concentrate at domestic mines decreased 72% and consumer-held stocks of tungsten concentrate decreased 49%, compared with stocks held at yearend 1975. Producers' and consumers' stocks of APT decreased 16% from those of 1975. Producers' stocks of intermediate tungsten products decreased 15%, while consumers' stocks of intermediate products remained virtually the same, as indicated in tables 5 and 6.

Table 6.—Consumption and stocks of tungsten products in the United States, by end use

(Thousand pounds of contained tungsten)

End use	Ferro-tungsten[1]	Tungsten metal powder[2]	Tungsten carbide powder	Other tungsten materials[3]	Total
1975:					
Steel:					
Stainless and heat resisting	86	--	--	72	158
Alloy	69	--	--	70	139
Tool	566	--	--	326	892
Cast irons	4	--	--	--	4
Superalloys	77	69	--	233	379
Alloys (excludes steels and superalloys):					
Cutting and wear-resistant materials	--	2,316	5,709	330	8,355
Other alloys[4]	103	518	268	128	1,017
Mill products made from metal powder	--	1,490	W	--	1,490
Chemical and ceramic uses	--	--	W	310	310
Miscellaneous and unspecified	1	6	153	30	190
Total	906	4,399	6,130	1,499	12,934
Consumer stocks, Dec. 31	231	713	1,247	562	2,753

See footnotes at end of table.

Table 6.—Consumption and stocks of tungsten products in the United States, by end use —Continued

(Thousand pounds of contained tungsten)

End use	Ferro-tungsten[1]	Tungsten metal powder[2]	Tungsten carbide powder	Other tungsten materials[3]	Total
1976:					
Steel:					
Stainless and heat resisting	69	--	--	57	126
Alloy	97	--	--	147	244
Tool	682	--	--	451	1,133
Cast irons	4	--	--	--	4
Superalloys	90	137	W	208	435
Alloys (excludes steels and superalloys):					
Cutting and wear-resistant materials	--	3,744	6,081	577	10,402
Other alloys[4]	89	546	312	145	1,092
Mill products made from metal powder	--	2,432	W	--	2,432
Chemical and ceramic uses	--	--	W	704	704
Miscellaneous and unspecified	--	2	218	7	227
Total	1,031	6,861	6,611	2,296	16,799
Consumer stocks, Dec. 31	272	606	1,430	470	2,778

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."
[1]Includes melting base self-reducing tungsten.
[2]Includes both carbon-reduced and hydrogen-reduced tungsten metal powder.
[3]Includes tungsten chemicals, natural and synthetic scheelite, tungsten scrap and other.
[4]Includes welding and hard-facing rods and materials and nonferrous alloys.

PRICES AND SPECIFICATIONS

In 1976, the average value of tungsten concentrate shipped from domestic mines and mills, as reported to the Bureau of Mines, increased 20% to $100.70 per short ton unit of WO_3, when compared with the 1975 value. During 1976, GSA sold excess tungsten concentrate for domestic use at prices, ex-duty, ranging from $81.74 to $127.07 per short ton unit. GSA sales of excess tungsten concentrate for export ranged from $78.87 to $127 per short ton unit.

The European price of tungsten concentrate, as quoted in the Metal Bulletin (London), reported in Metals Week, and shown in table 7, increased steadily each month from a low of £42 per metric ton unit (about $76.31 per short ton unit) in January to a high of £90 per metric ton unit (about $135.94 per short ton unit) at yearend. The increase in average price per short ton unit of WO_3 was 25% over the average price of $83.19 per short ton unit of 1975.

The price of APT delivered to large-volume contract customers was $106 per short ton unit at the beginning of the year. This low price for the year was maintained

Table 7.—Monthly price quotations of tungsten concentrate in 1976

Month	Wolfram and scheelite; London market, pounds sterling per metric ton unit of WO_3, 65% basis		Equivalent quotations, dollars per short ton unit of WO_3, 65% basis[1]		
	Low	High	Low	High	Average[2]
January	£42.00	£45.00	$76.31	$82.77	$79.57
February	43.50	46.00	80.11	84.70	82.59
March	45.00	51.75	82.71	90.30	86.64
April	51.00	58.50	86.52	97.07	91.06
May	58.00	62.75	96.70	102.38	99.38
June	62.00	64.00	96.12	103.09	100.51
July	62.50	64.00	100.93	103.93	102.35
August	63.50	72.75	102.83	116.97	109.99
September	71.00	75.00	112.52	118.33	115.70
October	74.25	81.50	111.82	121.74	116.13
November	83.50	90.00	118.66	135.94	128.13
December	[3]85.50	[3]88.20	130.18	134.26	132.16

[1]Equivalent high and low quotations as reported in Metals Week from biweekly Metal Bulletin (London) data; price dependent upon the prevailing rate of currency exchange.
[2]Arithmetic average of weekly quotations. The equivalent 1976 average price, excluding duty, was $103.68 per short ton unit.
[3]In December, due to new Bank of England Exchange control regulations, the Metal Bulletin (London) quotations were changed to U.S. dollars per metric ton unit and ranged from $143.50 to $148.00 per metric ton unit. The December 1976 foreign exchange average of $1.678 for the pound sterling was used in making the conversion.

until August 1976, when it was increased to $135 per short ton unit. The price of "Blue Oxide" (W_2O_5) remained at $2 per short ton unit above the APT price plus a 1% surcharge to cover processing losses.

The conversion fee of $18.50 per short ton unit in effect on January 1976 was maintained throughout 1976 for toll-processing tungsten concentrate to APT at a recovery rate of approximately 96%.

The price of hydrogen-reduced tungsten metal powder (99.99% purity), f.o.b. shipping point, as quoted in Metals Week, was $10.21 to $12.01 per pound of contained tungsten from January to October 1. In October, the price range increased to $10 to $13. Within these ranges, the price depended primarily on the tungsten powder particle size (Fisher number).

UCAR ferrotungsten is a proprietary high-purity ferroalloy containing 90% tungsten. In January, its price was quoted at $7.75 per pound of contained tungsten, rising to $7.95 on June 1, to $8.40 on August 1, and to $9.25 on November 1.

The price of scheelite concentrate (calcium tungstate) for direct addition to steel melts was believed to be comparable to the prices reported in table 7.

FOREIGN TRADE

Exports.—During 1976, tungsten concentrate exports continued to represent excess materials purchased from GSA stockpiles and increased 31% to 1.7 million pounds of tungsten in concentrate. There were no exports of ferrotungsten during 1976. On the other hand, APT exports increased 41% to 188,360 pounds of contained tungsten with the United Kingdom as the principal recipient. In 1976, exports of WC powder increased 58% to 1.3 million pounds of contained tungsten. Mexico (26%), Canada (24%), West Germany (11%), Sweden (6%), and Iran (6%), received 73% of the exports.

Exports of unwrought tungsten metal and alloys in crude form including waste and scrap increased 27% to 1,099,169 pounds gross weight, valued at $3,260,499 and were shipped primarily to West Germany (65%), the United Kingdom (12%), and Belgium-Luxembourg (10%). Exports of tungsten and tungsten alloy powder decreased 3% to 610,858 pounds of contained tungsten valued at $3,836,671. The principal recipients were Israel (60%), the United Kingdom (13%), Canada (9%), and Austria (5%).

Exports of tungsten and tungsten alloy wire increased 22% to 194,718 pounds, gross weight, valued at $6,219,902, and were received mainly by Canada (27%), West Germany (12%), Brazil (11%), Israel (6%), Japan (6%), Mexico (6%), Italy (5%), and the U.S.S.R. (5%). Exported wrought tungsten and tungsten alloys increased 5% to 241,727 pounds, gross weight, valued at $3,637,310. These materials were shipped mainly to West Germany (35%), Canada (14%), Sweden (14%), the United Kingdom (12%), and Mexico (7%).

Table 8.—U.S. exports of tungsten ore and concentrate, by country

(Thousand pounds and thousand dollars)

Country	1975			1976		
	Gross weight	Tungsten content[1]	Value	Gross weight	Tungsten content[1]	Value
Austria	--	--	--	56	29	141
Belgium-Luxembourg	1	(2)	4	30	16	79
France	119	62	388	122	63	600
Germany, West	1,223	631	3,875	965	498	2,973
Italy	7	3	40	--	--	--
Japan	--	--	--	505	260	1,751
Netherlands	1,191	614	3,756	1,216	628	4,225
Sweden	--	--	--	11	6	30
Switzerland	--	--	--	30	15	89
United Kingdom	11	6	19	344	177	1,052
U.S.S.R	--	--	--	72	37	249
Total	2,552	1,316	8,082	3,351	1,729	11,189

[1]Tungsten content estimated by multiplying the gross weight by a factor of 0.516 equal to 0.65 (to convert from 65% to 100% WO_3 basis) times 0.7931 (to convert from WO_3 to W basis).
[2]Less than 1/2 unit.

Table 9.—U.S. exports of ammonium paratungstate, by country

Country	1975			1976		
	Gross weight (pounds)	Tungsten content[1] (pounds)	Value	Gross weight (pounds)	Tungsten content[1] (pounds)	Value
Canada	--	--	--	40,000	28,264	$253,865
El Salvador	--	--	--	200	141	3,347
Germany, West	44,700	31,585	$277,034	4,556	3,220	30,660
Jamaica	310	219	4,004	--	--	--
Netherlands	143,500	101,397	643,683	--	--	--
New Zealand	183	130	2,300	--	--	--
Philippines	122	86	1,021	137	97	1,000
United Kingdom	--	--	--	220,650	155,911	1,412,000
Venezuela	--	--	--	1,029	727	4,410
Total	188,815	133,417	928,042	266,572	188,360	1,705,282

[1]Tungsten content estimated by multiplying gross weight by 0.7066.

Table 10.—U.S. exports of tungsten carbide powder, by country

Country	1975			1976		
	Gross weight (pounds)	Tungsten content[1] (pounds)	Value	Gross weight (pounds)	Tungsten content[1] (pounds)	Value
Argentina	1,582	1,234	$20,194	10,574	8,248	$167,010
Australia	2,261	1,764	22,085	13,181	10,281	108,222
Austria	2,200	1,716	20,900	63,153	49,259	591,013
Belgium-Luxembourg	24,701	19,267	152,792	57,225	44,635	214,521
Belize	25	19	2,585	--	--	--
Brazil	11,089	8,649	83,137	22,754	17,748	253,662
Canada	340,524	265,609	2,377,549	381,760	297,773	2,223,783
Chile	254	198	3,500	2,653	2,069	25,000
Colombia	57	44	2,695	57	44	2,695
Costa Rica	400	312	5,100	--	--	--
Denmark	4,359	3,400	35,003	5,483	4,277	51,260
Finland	60	47	1,105	50	39	726
France	32,757	25,550	246,448	7,702	6,008	58,071
Gabon	--	--	--	1,000	780	10,800
Germany, West	115,693	90,240	682,369	171,397	133,690	1,436,085
Hong Kong	--	--	--	8,881	6,927	3,998
Iran	88,513	69,040	65,719	91,445	71,327	18,251
Ireland	550	429	5,087	1,722	1,343	24,896
Israel	38,771	30,241	320,807	30,000	23,400	4,320
Italy	105,137	82,008	604,614	57,955	45,205	454,980
Japan	4,361	3,402	40,168	82,836	64,612	771,183
Kuwait	100	78	1,394	--	--	--
Mexico	r88,958	r69,387	727,655	428,988	334,611	437,209
Netherlands	43,601	34,009	323,062	29,387	22,922	261,485
New Zealand	10,081	7,863	26,007	--	--	--
Nigeria	8,182	6,382	12,695	--	--	--
Norway	5,593	4,363	6,806	643	502	7,105
Peru	10,907	8,507	9,196	2,000	1,560	4,280
Philippines	6,189	4,827	56,746	2,395	1,868	1,032
Portugal	--	--	--	110	86	1,374
Qatar	1,800	1,404	2,084	--	--	--
Singapore	4,250	3,315	27,709	82	64	1,184
South Africa, Republic of	21,700	16,926	124,358	1,856	1,448	26,723
Southern Asia, n.e.c	4,000	3,120	1,902	--	--	--
Spain	14,312	11,163	161,700	2,057	1,604	33,278
Surinam	600	468	1,000	--	--	--
Sweden	8,080	6,302	76,503	94,253	73,518	501,356
Switzerland	14,528	11,332	164,704	17,350	13,533	110,250
Taiwan	1,125	878	12,790	30	23	780
Trinidad and Tobago	318	248	2,389	--	--	--
Turkey	550	429	7,501	100	78	2,320
United Arab Emirates	--	--	--	5,000	3,900	10,231
United Kingdom	8,833	6,890	98,002	29,465	22,983	127,242
Venezuela	100	78	1,095	398	310	3,813
Total	r1,027,101	r801,138	6,537,155	1,623,942	1,266,675	7,950,138

rRevised.
[1]Tungsten content estimated by multiplying gross weight by 0.78.

Table 11.—U.S. exports of tungsten and tungsten alloy powder, by country

Country	1975 Gross weight (pounds)	1975 Tungsten content[1] (pounds)	1975 Value	1976 Gross weight (pounds)	1976 Tungsten content[1] (pounds)	1976 Value
Argentina	1,000	800	$10,706	--	--	--
Australia	1,170	936	10,508	434	347	$4,354
Austria	39,463	31,571	267,249	37,321	29,857	$253,933
Belgium-Luxembourg	54,623	43,699	377,315	2,705	2,164	24,166
Brazil	508	406	4,023	1,243	995	14,300
Canada	63,707	50,966	640,365	67,554	54,043	706,460
Denmark	1,097	878	9,000	--	--	--
Finland	9,038	7,230	65,041	4,312	3,450	40,918
France	1,048	838	15,193	1,501	1,201	16,726
Germany, West	51,905	41,524	123,341	28,417	22,734	181,987
India	38	30	1,010	--	--	--
Ireland	2,240	1,792	32,118	3,308	2,646	41,443
Israel	460,224	368,179	3,322,663	457,074	365,659	1,202,601
Italy	9,180	7,344	46,196	2,005	1,604	18,920
Japan	11,022	8,818	62,500	1,915	1,532	10,623
Mexico	3,410	2,728	33,139	6,959	5,567	63,237
Netherlands	--	--	--	236	189	1,128
Singapore	40,000	32,000	265,232	--	--	--
Spain	294	235	1,474	330	264	5,625
Sweden	--	--	--	28,109	22,487	260,455
Switzerland	4,574	3,659	30,670	118	94	1,104
Taiwan	2,000	1,600	28,590	3,051	2,441	49,778
Turkey	--	--	--	13,411	10,729	136,294
United Kingdom	27,194	21,755	208,331	99,709	79,767	775,089
Venezuela	900	720	9,762	3,860	3,088	27,530
Total	784,635	627,708	5,564,426	763,572	610,858	3,836,671

[1]Tungsten content estimated by multiplying gross weight by 0.80.

Table 12.—U.S. imports[1] of tungsten ore and concentrate, by country

(Thousand pounds and thousand dollars)

Country	1975 Gross weight	1975 Tungsten content	1975 Value	1976 Gross weight	1976 Tungsten content	1976 Value
Australia	707	390	1,995	311	172	864
Bolivia	1,888	1,037	4,868	1,753	963	4,900
Brazil	336	187	1,012	4	2	11
Burma	308	160	815	232	123	582
Burundi	--	--	--	7	3	16
Canada	3,815	1,585	7,769	4,101	1,343	7,656
Chile	15	8	40	--	--	--
China, People's Republic of	715	387	2,176	717	384	2,289
France	388	116	500	--	--	--
Guatemala	159	28	4	--	--	--
Hong Kong	--	--	--	78	43	121
Japan	88	50	198	--	--	--
Korea, Republic of	927	530	2,832	357	202	1,054
Malaysia	120	70	178	105	61	284
Mexico	983	419	1,914	927	440	2,279
Peru	1,509	862	4,143	1,458	839	4,450
Portugal	335	197	1,164	714	420	2,386
Rwanda	--	--	--	71	38	169
Singapore	--	--	--	19	10	59
South Africa, Republic of	83	27	68	26	15	69
South-West Africa, Territory of	88	50	195	--	--	--
Spain	24	14	66	36	21	119
Taiwan	44	23	124	--	--	--
Thailand	1,255	673	3,033	1,314	655	3,266
Uganda	35	18	56	--	--	--
United Kingdom	33	19	107	--	--	--
Zaire	109	58	236	125	68	376
Total	13,964	6,908	33,493	12,355	5,802	30,950

[1]Data are "general imports", that is, they include tungsten imported for immediate consumption plus material entering warehouses.

Imports.—Tungsten concentrate imported in 1976 for consumption decreased 19% from that imported in 1975 to 5.3 million pounds of contained tungsten. The major suppliers were Canada (25%), Peru (16%), Thailand (11%), and Bolivia (11%).

Tungsten carbide imports for the year increased 19% over those of 1975 to 194,432 pounds of contained tungsten valued at $2,184,376 and came primarily from West Germany (70%), France (12%), and Sweden (11%). Imports of tungsten waste and scrap containing over 50% tungsten increased 117% to 149,794 pounds of contained tungsten valued at $694,269. The imports came primarily from Israel (53%), Singapore (17%), Japan (10%), and Mexico (9%). Imports of unwrought tungsten (except alloys) in lump, grain, and powder forms increased 87% to 377,153 pounds of contained tungsten valued at $2,600,338 and were received mainly from West Germany (52%), France (14%), and Singapore (9%). Wrought tungsten imports increased 237% to 42,893 pounds, gross weight, valued at $1,966,446, and were supplied primarily by Canada (51%), Japan (27%), and Austria (15%).

Imports of tungsten material classified as "metal-bearing materials in chief value of tungsten" increased 433% to 378,528 pounds of contained tungsten valued at $2,224,743. The imports were received solely from Bolivia and are believed to be mostly synthetic scheelite. Ammonium tungstate imports decreased 30% to 582,622 pounds of contained tungsten valued at $3,699,178 and were supplied by the Republic of Korea (71%) and Japan (29%). Imports of calcium tungstate and sodium tungstate dropped to relatively insignificant quantities of 19,014 and 20,131 pounds of contained tungsten, respectively.

Table 13.—U.S. imports for consumption of tungsten ore and concentrate, by country

(Thousand pounds and thousand dollars)

Country	1975			1976		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Argentina[1]	--	--	--	23	10	46
Australia	707	390	1,995	311	172	864
Bolivia[1]	1,433	787	3,839	1,062	580	2,649
Brazil[1]	336	188	1,012	4	2	11
Burma[1]	308	160	815	232	123	581
Burundi[1]	--	--	--	7	3	16
Canada	3,839	1,600	7,862	4,101	1,343	7,656
Chile[1]	15	8	40	--	--	--
China, People's Republic of	569	310	1,752	703	377	2,256
France	388	116	500	--	--	--
Guatemala[1]	306	170	229	--	--	--
Japan	22	12	21	--	--	--
Korea, Republic of[1]	898	514	2,744	357	202	1,054
Malaysia[1]	120	70	178	86	49	207
Mexico[1]	983	419	1,914	883	417	2,166
Peru[1]	1,518	866	4,166	1,501	863	4,564
Portugal[1]	335	197	1,164	714	420	2,386
Rwanda[1]	--	--	--	70	38	169
Singapore[1]	--	--	--	19	10	59
South Africa, Republic of	83	27	68	26	15	69
Spain	24	14	66	36	21	118
Thailand[1]	1,217	629	2,901	1,193	588	3,073
Uganda	34	16	56	--	--	--
United Kingdom	33	19	107	--	--	--
Zaire[1]	109	58	236	125	68	376
Total	13,277	6,570	31,665	11,453	5,301	28,320

[1]Section 504(c) of the Trade Act of 1974 establishes a Generalized System of Preferences for the entry of tungsten from designated beneficiary developing countries. The program began January 1, 1976.

Table 14.—U.S. imports for consumption of ferrotungsten, by country

Country	1975 Gross weight (pounds)	1975 Tungsten content (pounds)	1975 Value	1976 Gross weight (pounds)	1976 Tungsten content (pounds)	1976 Value
Austria	158,989	131,609	$836,391	313,704	260,191	$1,744,103
France	44,092	34,058	225,703	312,172	246,447	1,502,085
Germany, West	22,046	18,122	107,393	64,588	52,920	292,170
India	--	--	--	39,262	32,077	251,209
Japan	44,092	35,331	204,528	--	--	--
Korea	--	--	--	4,409	3,349	18,959
Portugal	11,023	9,222	59,429	17,636	14,741	86,445
Sweden	--	--	--	24,692	20,001	147,831
United Kingdom	232,052	189,940	1,108,729	265,431	214,545	1,408,443
Total	512,294	418,282	2,542,173	1,041,894	844,271	5,451,245

Table 15.—U.S. imports for consumption of tungsten and tungsten carbide forms

(Thousand pounds and thousand dollars)

Year	Ingots, shot, bars, and scrap: Quantity	Ingots, shot, bars, and scrap: Value	Wire, sheets, and other forms, n.s.p.f.: Quantity	Wire, sheets, and other forms, n.s.p.f.: Value	Total: Quantity	Total: Value
1974	680	1,823	1,782	7,545	2,462	9,368
1975	438	2,548	1,460	8,556	1,898	11,104
1976	1,303	5,791	1,170	8,464	2,473	14,255

Table 16.—U.S. import duties on all forms of tungsten

Tariff classification	Article	Rate of duty effective Jan. 1, 1977: Prevailing[1]	Rate of duty effective Jan. 1, 1977: Statutory
601.5400	Tungsten ore	25 cents per pound on tungsten content	50 cents per pound on tungsten content.
603.4500	Other metal-bearing materials in chief value of tungsten.	21 cents per pound on tungsten content and 10% ad valorem.	60 cents per pound on tungsten content and 40% ad valorem.
607.6500	Ferrotungsten	21 cents per pound on tungsten content and 6% ad valorem.	60 cents per pound on tungsten content and 25% ad valorem.
629.2500	Waste and scrap containing by weight not over 50% tungsten.	do	Do.
629.2600	Waste and scrap containing by weight over 50% tungsten.	10.5% ad valorem	50% ad valorem.
629.2800	Unwrought tungsten, except alloys, in lump, grain, and powder.	21 cents per pound on tungsten content and 12.5% ad valorem.	60 cents per pound on tungsten content and 50% ad valorem.
629.2900	Unwrought tungsten, ingots and shot.	10.5% ad valorem	50% ad valorem.
629.3000	Unwrought tungsten, n.e.c	12.5% ad valorem	60% ad valorem.
629.3200	Tungsten alloys, unwrought, containing by weight over 50% tungsten.	21 cents per pound on tungsten content and 6% ad valorem.	60 cents per pound on tungsten content and 25% ad valorem.
629.3300	Tungsten alloys, unwrought, containing by weight not over 50% tungsten.	12.5% ad valorem	60% ad valorem.
629.3500	Wrought tungsten	do	Do.
416.4000	Tungstic acid	21 cents per pound on tungsten content and 10% ad valorem.	60 cents per pound on tungsten content and 40% ad valorem.
417.4000	Ammonium tungstate	do	Do.
418.3000	Calcium tungstate	do	Do.
420.3200	Potassium tungstate	do	Do.
421.5600	Sodium tungstate	do	Do.

See footnotes at end of table.

Table 16.—U.S. import duties on all forms of tungsten —Continued

Tariff classification	Article	Rate of duty effective Jan. 1, 1977	
		Prevailing[1]	Statutory
422.4000	Tungsten carbide	21 cents per pound on tungsten content and 12.5% ad valorem.	60 cents per pound on tungsten content and 50% ad valorem.
422.4200	Other tungsten compounds	21 cents per pound on tungsten content and 10% ad valorem.	60 cents per pound on tungsten content and 40% ad valorem.
423.9200	Mixtures of two or more inorganic compounds in chief value tungsten.	do	Do.

[1]Not applicable to most centrally controlled economy countries.

WORLD REVIEW

In two meetings of the United Nations Committee on Tungsten in 1976, discussions were continued on methods to stabilize tungsten prices. At the first meeting in January producers and consumers only agreed that a concentrate containing 65% WO_3 would be the basis for any price stabilization measures. At the second meeting in November, the producers, led by Bolivia, urged the establishment of a group of experts (producer and consumer) to draft a formal price stabilization agreement. The meeting ended without an agreement, and further negotiations were put off until after a special United Nations Conference On Trade and Development (UNCTAD) board session in 1977. The proposed agreement, outlined at the November 1976 meeting of UNCTAD, suggested establishing a system of maximum and minimum prices that would be supported at appropriate times by coordinated nationally held stockpiles and be combined with restrictions on both imports and exports.

Australia.—The King Island Scheelite Mine Division, Peko-Wallsend Ltd., the major producer of tungsten in Australia, developed the Bold Head and Dolphin mines so that 386,000 short tons per year of ore could be produced from underground operations, with the potential of 440,000 tons per year. In 1976, 329,350 tons of ore, averaging 0.77% WO_3, was treated to produce 2,600 tons of concentrate, averaging 72.7% WO_3.

A decision was made to install an artificial scheelite plant to produce a molybdenum-free calcium tungstate product from the flotation concentrate. The plant was scheduled to be completed in early 1978.[3]

Austria.—The Miltersill scheelite mine of Wolfram-Bergbau and Hüttengesellschaft mbH, Metallgesellschaft AG, and Teledyne Inc. began production in late August. The concentrate was sold while the processing plant was under construction. When the processing plant is completed in early 1977, it will become part of the second integrated tungsten production facility in Europe, and the fourth in the world. The plant's production capacity will be 1,490 tons of contained tungsten per year. The tungsten will be sold in a variety of forms: Carbide powder, pure tungsten powder, blue oxide, APT, and tungsten concentrate. When operational, the plant is expected to meet 10% of Western Europe's demand for tungsten. Reserves were estimated at 3.1 million tons, containing 0.7% to 1% WO_3. The mine has an estimated life of 8 to 10 years, based on proven reserves.

Bolivia.—Bolivian tungsten is primarily in wolframite, ranging between huebnerite and ferberite. The Corporacíon Minera de Bolivia (COMIBOL) accounts for most of the tungsten production. The tungsten mineralization belt extends along the general line of the Eastern Cordillera of the Andes from Peru to Argentina. In the north, mineralization follows closely the tin deposits related to granitic batholiths of the Cordillera Real and Quimsa Cruz. In the south, mineralization is related closely to deposits of antimony, zinc, and silver.

International Mining Co. (IMCO), a subsidiary of Estalsa S.A., planned to expand the capacity of its Chojlla mine and mill. A new beneficiation plant reportedly will be installed to treat tailing dumps containing 0.22% tin and tungsten (about 50% of each). The plant would have a capacity to process 4,410 tons per day. Tailing processing should increase the company's output of tungsten contained in WO_3 by 358 tons per year, and operations will begin in early 1977.

[3]Peko-Wallsend Ltd., (Sydney, Australia). Annual Report 1975-76. 32 pp.

Table 17.—Tungsten: World mine production, by country

(Thousand pounds of contained tungsten)[1]

Country	1974	1975	1976[p]
North and Central America:			
Canada[2]	2,822	2,584	[e]3,530
Guatemala	14	2	--
Mexico	681	611	518
United States	7,381	5,588	5,830
South America:			
Argentina	[r]207	190	[e]180
Bolivia	[3]4,471	[3]5,661	[4]6,700
Brazil	2,189	2,496	[e]2,650
Peru	[r]1,550	1,283	1,303
Europe:			
Austria	--	798	1,193
Czechoslovakia[e]	175	175	175
France	[r]1,574	1,367	1,775
Portugal	[r]3,236	3,139	2,813
Spain	[r]765	774	611
Sweden	[r]474	315	[e]440
U.S.S.R.[e]	16,800	17,200	17,600
United Kingdom	[r]22	22	[e]22
Africa:			
Burundi	1	2	4
Nigeria	([5])	([5])	[e]([5])
Rhodesia, Southern[6]	201	84	55
Rwanda	[r]624	761	[e]840
Southwest Africa, Territory of[7]	--	16	18
Tanzania	1	([8])	--
Uganda[e]	240	240	240
Zaire	432	547	529
Asia:			
Burma	750	728	1,032
China, People's Republic of	18,700	19,800	19,800
India	27	43	51
Japan	[r]1,786	1,693	1,795
Korea, North[e]	4,740	4,740	4,740
Korea, Republic of	5,046	5,298	5,655
Malaysia	289	234	141
Thailand	[r]4,497	3,609	4,180
Turkey	--	--	2,046
Oceania:			
Australia	[r]3,128	4,262	5,379
New Zealand	9	--	--
Total	[r]82,832	84,262	91,845

[e]Estimate. [p]Preliminary. [r]Revised.

[1]Conversion factors: WO_3 to W, multiply by 0.7931; 60% WO_3 to W, multiply by 0.4758.

[2]Producer's shipments; actual production data are not officially reported, but available company figures indicate a substantial difference between actual output and shipments in some years.

[3]Data presented are sum of production reported by COMIBOL and exports credited to medium and small mines and other unspecified exporters (including COMIBOL). Total national output is not reported.

[4]Actual recorded total national output. Not available for prior years.

[5]Less than 1/2 unit.

[6]Production of Beardmore mine only.

[7]Production of Brandberg West mine of South West Africa Company, Ltd. only. Data are for calendar years.

[8]Revised to zero.

COMIBOL tungsten reserves were estimated as follows: Bolsa Negra, 442,000 tons at 1% WO_3; Kami, 100,000 tons at 0.98% WO_3; Viloco, 2,210 tons at 0.98% WO_3; Esmoraca, 1,990 tons at 1.8% WO_3. IMCO reserves were estimated as follows: Chojlla, 2,210,000 tons at 1% WO_3; Chambillaya, 496,000 tons at 1% WO_3; Enrramada, 551,000 tons at 1% WO_3; San José Bergue, 55,100 tons at 1% WO_3; Santa Isabel, 11,000 tons at 1% WO_3. Various small mines had reserves estimated at 160,000 tons averaging 1.05% WO_3.[4]

Brazil.—A new tungsten company, Brejui Mineração e Metallurgia S.A., was established by Nittetsu Mining Co., Kanematsu-Gosho Ltd., and a local company Mineração Tomaz Salustino S.A. The new company will produce 130 tons per year of synthetic scheelite from tailings in the Currais Novos region. A pilot plant for the production of 70% to 75% scheelite concentrate from 0.2% ore also was scheduled for construction in 1977, at the site of the large Brejui tungsten mine.

Union Carbide Corp. brought its new tungsten mine and mill in Boca DeLage onstream in December 1976. The operation is scheduled to produce 1 million pounds per

[4]U.S. Embassy, La Paz, Bolivia. Industrial Outlook Report. State Department Airgram A-86, Aug. 2, 1976.

Table 18.—Tungsten: World concentrate consumption, by country

(Thousand pounds of contained tungsten)

Country[1]	1974	1975	1976[p]
Actual consumption:			
Australia	88	88	[e]90
Austria	2,310	2,008	[e]3,000
Canada	602	269	[e 2]375
Czechoslovakia[e 2]	2,745	2,700	2,700
France	3,926	3,179	3,139
Japan	6,466	4,773	5,677
Portugal	831	780	595
Sweden	3,702	3,629	3,761
United Kingdom	6,116	4,967	4,251
United States	16,299	14,013	16,107
Apparent consumption, excluding stock variations:[3]			
Argentina	150	121	[e 2]130
Belgium-Luxembourg	313	90	401
Brazil	315	613	[e 2]620
China, People's Republic of[e 2]	4,500	4,600	4,700
Germany:			
East[e 2]	600	550	600
West	4,068	2,551	4,464
Hungary[e]	[r]1,320	[r]1,320	1,320
India	326	[e]310	[e 2]310
Korea:			
North[e 2]	3,500	3,500	3,500
Republic of[e 4]	1,400	1,500	1,600
Netherlands	[r]4,495	2,465	[e]2,593
Poland	3,730	3,549	4,231
South Africa, Republic of[e]	573	550	550
Spain	231	132	[e]148
U.S.S.R.[e 2]	14,900	[r]15,300	16,100
Total	[r]83,506	73,557	80,962

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, Bulgaria, Denmark, Finland, Israel, Norway, Romania, Switzerland, and Yugoslavia may consume tungsten concentrate, but consumption levels are not reported and available general information is inadequate to permit formulation of reliable estimates of consumption levels.

[2]Estimated by U.S. Bureau of Mines. (All estimates not so footnoted are reported in the primary source.)

[3]Production plus imports minus exports.

[4]Data represents tungsten content of concentrate consumed to make ammonium paratungstate at APT plant adjacent to Sangdong mine and mill.

year of tungsten in concentrate. The output will be marketed by UCORE Ltd., London, a trading company wholly owned by Union Carbide.

Canada.—Canada Tungsten Mining Corp. Ltd. (CTMC) planned to double the mill capacity at its Flat River mine in the Northwest Territories to 1,000 tons of ore per day. Construction of additional facilities was planned for the summer of 1977. CTMC's mill treated 188,934 tons of scheelite ore, averaging 1.55% WO_3, during the year. Total production was 238,998 short ton units of WO_3, an increase of 33% over that of 1975. Mill recovery was 81.6% in 1976, compared with 71.1% in 1975. The concentrator operated at a rate of 523 tons per day with an overall efficiency of 97.8%. Minable ore reserves at yearend were estimated to be 4,190,000 tons of ore, grading 1.55% WO_3. Exploration, development, and diamond drilling added about 857,000 tons, averaging 1.65% WO_3, to the ore reserve in 1976.[5]

India.—Production of tungsten concentrate from two mines totaled 97,372 pounds, an increase of 18% over that of 1975. Over 80% of this production was from Rajasthan, with the remainder coming from West Bengal. Imports of tungsten concentrate into India totaled 828,937 pounds valued at $2.4 million, Thailand and Bolivia were the major suppliers.

Korea, Republic of.—The Ministry of Commerce and Industry reported that 5,138 tons of tungsten in concentrate was produced in Korea during 1976 by the following companies:

Company	Short tons of contained tungsten
Chungyang Mining Co., Ltd.	160
Korea Tungsten Mining Co., Ltd.	4,619
Okbang Mining Co., Ltd.	71
Other companies	288
Total	5,138

Korea Tungsten Mining Co., Ltd., 8.7% owned by the Republic of Korea, increased production by 86% and accounted for al-

[5]Canada Tungsten Mining Corp. Ltd., (Toronto, Canada). 1976 Annual Report. 9 pp.

most 90% of the country's tungsten output. The Economic Planning Board reported that stocks on hand at yearend 1976 were 540 tons.

Rwanda.—The larger of two competing wolframite mining operations was absorbed by Société Minière du Rwanda (SOMIRWA), which in 1976 mined over 93% of Rwanda's yearly output. Concentrate output is relatively high grade, containing about 70% WO_3, and was sold directly through GEOMINES, a Brussels-based company.

Thailand.—Production of tungsten concentrate in 1976 totaled 4,384 tons, averaging 65% WO_3, an increase of 25% over that of 1975.

Turkey.—Etibank's new Uludas tungsten mine and mill was nearly ready for inauguration by yearend. The deposit is near the near the summit of Uludas Mountain and is in two sections. The upper section is low grade and garnetiferous, while the lower section is granitic and averages about 0.4% WO_3. Mining is by underground methods, and the concentrator, employing magnetic separation and tabling, has a capacity of about 3,300 tons of concentrate per year at about 65% WO_3. The mine is owned and operated by the Turkish State mining enterprise Etibank, and the cost of development was reportedly about $90 million.

United Kingdom.—An extensive drilling program was underway at the Hemerdom tungsten-tin and kaolin mine near Plymouth to prove the extent of mineralization. Tungsten mineralization averages 0.29% WO_3, and it was hoped that an orebody of 50 million tons could be proved. The old mine was operated underground, but any new venture would use open pit methods.[6]

Weco Development Corp. of the United States announced that it granted a 1-year option, beginning September 1, 1976, to the Carrock Fell Mining Company Ltd. (part of the Amalgamated Industrials Ltd. in the United Kingdom) and to Robertson Research International Ltd., an international engineering-consulting firm, to reopen Weco's Carrock Fell tungsten mine. This consortium intends to undertake a development and evaluation program and to modify and improve the mill. If the new operators exercise their option to place the mine into production on a continuing basis, Weco will retain a 31.5% interest in the mine and mill, including 3,500 acres of land.

TECHNOLOGY

Bureau of Mines researchers successfully coated two large steel valve seats with an adherent deposit of tungsten for test in an experimental coal gasifier to determine their ability to withstand wear, abrasion, and corrosion at temperatures up to 1000°C. Approximately 0.6 pound of metallic tungsten was deposited on each seat by a chemical vapor deposition technique. Advantages gained by this method were the ease of application and the requirement of only moderate temperatures during application.

Studies were continued during the year by Bureau of Mines research metallurgists to develop a process to recover tungsten economically from the low-grade brine deposits of Searles Lake, Calif. These deposits contain about 35 million pounds of tungsten.

According to manufacturers, cutting tools made by the particle metallurgy process are replacing carbide and high-speed-steel products. The process is especially useful in blended alloys of cobalt and tungsten. Unlike the powder metallurgy process, in which powder is compacted under high pressure, particle metallurgy involves heating the particles to a molten temperature and then cooling the material in a vacuum.

Industrial research was reported on coatings, such as titanium and hafnium nitrides and alumina, and tungsten carbide cutting tools as well as changes in tool shapes such as fluting and layer webs.[7] Coated tools combine the strength of the tungsten substrate with the hardness and reduced friction of coatings that minimize cratering. In particular, the coated tools are excellent for roughing steel, whereas a solid tungsten carbide tool is excellent for finishing operations on medium steels at lighter feeds and speeds. The latest coating development uses a tungsten carbide substrate with triple-phase coatings of which the first layer is titanium carbide, the second layer is titanium carbonitride, and the outside coating is titanium nitride. The titanium carbonitride provides a better bond between the coatings.[8]

Field tests were conducted by Teledyne Firth Sterling on tungsten carbide tools coated with hafnium nitride (0.002 inch thick). The coated tools have a higher

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[6]Metal Bulletin. Hemerdon Reincarnation. No. 6144, Nov. 19, 1976, pp. 26.

[7]Mari, A. Technology Moves Ahead in Cutting Tools. Amer. Metal Market, v. 83, No. 81, April 1976, pp. 21-30.

[8]Work cited in footnote 2.

temperature hardness since the hafnium nitride has more lubricity than hafnium carbide, thereby reducing the cratering problem. These coated tools perform best on highly alloyed steels that generate a strong chip.[9]

General Electric Co.'s Carboloy Systems Department introduced a line of tungsten carbide disposable inserts coated with alumina for cutting metal in applications where cutting speeds are beyond the capabilities of tungsten carbide tools coated with titanium carbide and where solid oxide tools tend to break. The chemical inertness of alumina makes it an excellent material for high-speed machining (above 500 surface feet per minute). Below 500 surface feet per minute, titanium carbide is more resistive to abrasive wear, the primary cause of insert failure in that speed range.[10].

An entirely different design of a carbide cutter tool, the Dust Hog, was introduced by Mining Tools Inc. and is claimed to have substantially better performance characteristics than conventional mining bits. The new drilling bit features layer webs and places the dust holes closer to the tungsten carbide cutting edge for more efficient drilling and dust collection. The tool is claimed to run cooler, to provide 55% faster penetration, and to have 50% longer life in dry drilling applications. The design change includes a hexagonal coupling between the bit and steel chuck that is more rigid, is almost impossible to break, and produces straighter holes by eliminating bit wobble.[11]

General Electric researchers completed a project for the Marshall Space Flight Center to improve the service properties of tungsten for uses such as X-ray targets. The researchers designed and tested a facility which permits the levitation melting of tungsten through electromagnetic levitation with electron-beam heating. Not only does this process provide a means of growing tungsten crystals for the production of X-ray targets, but it also can deposit tungsten onto molybdenum by vapor deposition from a superheated melt. Several advantages were claimed for the process in that the targets produced were reported to have a greater exposure life, greater strength, and enhanced room temperature ductility.[12]

Several patents were issued during the year relating to tungsten recovery. One patent concerned the separation of tungsten and molybdenum when the two metals occur together in solution.[13] A second patent related to the extraction of tungsten from solutions containing the metal. The solvent extraction occurs by utilizing ammonium hydroxide and about 36% silica by weight to convert the tungsten to soluble ammonium metatungstate.[14]

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[9]Page 28 of work cited in footnote 2.

[10]American Metal Market. V. 83, No. 179, Sept. 13, 1976, p. 17.

[11]Mining Journal (London). V. 287, No. 7365, Oct. 15, 1976, p. 299.

[12]Marshall Space Flight Center. Containerless Processing of Tungsten. NASA Tech Briefs, MFS-23509, Fall 1976, p. 454.

[13]Bellingham, A. I. (assigned to Warmen Equipment (International) Ltd.). Process for the Separation of Tungsten and Molybdenum. U.S. Pat. 3,939,245, Feb. 17, 1976.

[14]Ritsko, J. E. (assigned to GTE Sylvania, Inc.). Process for Producing Ammonium Paratungstate From Ammonium Tungstate by Digestion in Silica. U.S. Pat. 3,956,474, May 11, 1976.

Uranium

By James H. Jolly[1]

The search for uranium continued to accelerate worldwide in 1976, owing to high uranium prices and expanding nuclear power programs. Both U.S. and world uranium reserves increased significantly. U.S. reserves at forward costs to $30 per pound of U_3O_8 were estimated at 680,000 tons of U_3O_8, a 40,000-ton increase, and world reserves at $30, exclusive of central economy countries, were estimated at 2.4 million tons of U_3O_8.

In the United States, most States had some level of uranium exploration activity. The Energy Research and Development Administration (ERDA) continued to expand its uranium reconnaissance activities under the National Uranium Resource Evaluation (NURE) program. Interest in low-grade uranium resources increased. Land acquisition and exploration drilling were at alltime highs. Mining activity continued high, and the gross tonnage of ore mined exceeded last year's record. The number of producing mines increased dramatically over that of 1975. In 1976, underground mines totaled 209, open pit mines 44, and other sources 28, compared with 121 underground mines, 23 open pits, and 25 other sources producing in 1975. More ore was milled in 1976 than during any previous year. Although milled ore increased almost 19%, uranium production increased only about 10% owing to lower ore grades and poorer mill recoveries. The millfeed grade averaged 0.15% U_3O_8 in 1976, down from 0.16% in 1975 and 0.17% in 1974. Sixteen conventional mills and two plants that recover uranium from in situ leaching solutions operated in 1976. Uranium recovery from phosphate rock was hampered by technical problems.

Uranium production was expected to increase rapidly in the next few years. A number of major new mines and associated mills were nearing startup, under construction, or planned. New developments were primarily underway in New Mexico and Wyoming. Increased emphasis was placed on recovery of uranium by solution mining, primarily in Texas and Wyoming, where a number of operations were starting up and planned. In Florida and Louisiana, increased production of uranium from phosphate rock was also anticipated.

In other sectors of the nuclear fuel cycle, legislation to aid the development of private uranium enrichment facilities was not approved making the future uncertain for proposals by four private groups. Programs to increase capacity at three Government enrichment plants continued, and plans to build an additional enrichment plant moved forward. A nuclear-fuel-reprocessing facility in South Carolina was almost completed; however, licensing problems and political decisions related to plutonium, proliferation, and waste management were delaying startup. In October, the President put a 3-year de facto moratorium on commercial fuel reprocessing and plutonium recycle. Waste management was a major concern. Long-term storage in stable geological formations continued to be the favored means of disposal.

Shortages of investment capital, concern for reactor safety, plutonium, radioactive waste, nuclear weapons proliferation, and reduced electricity demand continued to delay commercial nuclear power development. Problems related to nuclear proliferation, terrorism, and theft became major issues in 1976. Although public concern over nuclear power increased in 1976, voters in seven States voted down propositions designed to limit or stop construction of all future nuclear powerplants. The Price-Anderson Act, which provides financial protection to the public against losses

[1]Physical scientist, Division of Nonferrous Metals.

resulting from a nuclear accident, was extended for 10 years but was modified to enable the Government's indemnity to be phased out.

Seven new nuclear power plants became operable in 1976; however, there were orders for only three new plants, resulting in the smallest total megawatts ordered since 1965. At yearend, 65 plants were operable and 172 were under construction or planned. Nuclear powerplants generated 9.4% of the Nation's electrical energy in 1976, up from 8.9% in 1975. Overall, nuclear power supplied 2.8% of the Nation's total energy needs in 1976.

In the rest of the world, nuclear power development continued at a strong pace, and by mid-1977 the rest of the world's total on-line nuclear megawatt capacity was expected to exceed that of the United States. At yearend, exclusive of the United States, there were 111 nuclear plants operable in 18 countries and 187 under construction or planned in 30 countries.

Table 1.—Salient uranium statistics

(Short tons of U_3O_8 unless otherwise specified)

	1972	1973	1974	1975	1976
Production:					
Domestic:					
Mine:[1]					
Ore ... thousand tons	6,418	6,537	7,116	7,365	9,198
Content of ore	13,667	13,588	12,413	12,300	14,000
Average grade of ore ... percent U_3O_8	.213	.208	.174	.164	.154
Recoverable[2]	12,880	12,901	11,614	11,439	12,573
Value[3] ... thousands	$162,272	$167,718	$192,560	$281,388	$404,830
Mill, concentrate[4]	12,900	13,235	11,528	11,600	12,700
World[e 5]	[r]25,625	[r]25,486	[r]24,616	26,677	30,100
Domestic delivery of concentrate, private	11,600	12,100	11,900	12,500	12,900
Imports, concentrate	2,329	5,605	1,835	1,226	5,537
Reserves[6] ... thousand tons	520	634	600	640	680
Employment[7] ... number of persons	6,403	6,595	7,293	9,672	12,612

[e]Estimate. [r]Revised.
[1]Receipts at mills; excludes uranium from leaching operations, mine waters, and refinery residues.
[2]Based on mill recovery factors.
[3]Market value based on recoverable U_3O_8 content and estimated average price.
[4]Includes marketable concentrate from leaching operations.
[5]Market economies only.
[6]At yearend; forward cost of $15 per pound U_3O_8 for 1972, and of $30 per pound U_3O_8 for 1973-76.
[7]In exploration, mining, and milling at yearend.

Principal source: Energy Research and Development Administration.

Exploration and Reserves.—According to an ERDA survey,[2] 108 companies reported expenditures of $171 million on uranium exploration activities in 1976, compared with expenditures of $122 million in 1975. Foreign interests in 15 companies accounted for $13 million, or about 8% of total exploration expenditures. At yearend, 96 companies reported uranium exploration holdings of almost 15 million acres, 26% more than in 1975. During 1976, 4.75 million acres were acquired at a cost of $14 million. The cost per acre ranged from less than 10 cents to more than $200, averaging $2.92, down from $4.80 in 1975.

In 1976, more than 67,000 surface holes were drilled by 113 companies using an estimated 200 drill rigs. Total exploration and development drilling footage was a record 34.8 million feet, 37% more than in 1975. Exploration costs, including drilling, access roads, site preparation, geologic and technical work, sampling, and logging, ranged from $1 to $25 per foot, averaging $3.13 per foot, an 8% increase over costs in 1975.

Ten companies reported 350,000 feet of surface drilling exclusively for solution mining production in 1976 at a cost of $1.83 million, averaging $5.23 per foot drilled.

[2]Energy Research and Development Administration, Grand Junction (Colo.) Office. Uranium Exploration Expenditures in 1976 and Plans in 1977-78. GJO - 103, 1977, 10 pp.

Table 2.—Surface drilling for uranium

	1975	1976[e]
Number of holes	55,900	67,600
Type of drilling:[1]		
Exploration ____ thousand feet__	15,690	20,360
Development ________ do____	9,730	14,440
Total __________ do____	25,420	34,800
Average depth per hole ______ feet__	460	510

[e]Estimate.
[1]Does not include claim validation or underground long hole and diamond drilling.

Source: Energy Research and Development Administration.

Table 3.—Distribution of drilling by State

State	1975		1976	
	Total footage (millions)	Approximate percent of total	Total footage (millions)	Approximate percent of total
Wyoming	12	47	12	34
New Mexico	6	22	11	32
Texas	3	13	3	9
Colorado	1	4	3	9
Utah	2	7	2	6
Other[1]	2	7	3	10
Total	26	100	34	100

[1]Includes Alaska, Arizona, California, Idaho, Nevada, Nebraska, North Dakota, Oregon, Oklahoma, South Dakota, Washington, and Eastern United States.

Source: Energy Research and Development Administration.

New Mexico and Wyoming continued to be the leading States in uranium reserves with a combined total of 86% of the $10 reserves and 83% of the $15 reserves. ERDA estimates of yearend reserves by State at a cost of $30 per pound of U_3O_8 were:

State	Tons of ore (millions)	Grade (percent U_3O_8)	Tons of U_3O_8	Percent of total tons of U_3O_8
New Mexico	328	0.11	357,000	52
Wyoming	308	.07	[1]216,000	32
Texas	87	.05	[1]44,000	7
Arizona, Colorado, Utah	39	.11	43,000	6
Others[2]	24	.08	20,000	3
Total	786	.09	680,000	100

[1]Includes low grade reserves recoverable at $30 per pound by solution mining.
[2]California, Idaho, Montana, Nevada, North Dakota, Oregon, South Dakota, and Washington.

Source: Energy Research and Development Administration.

ERDA reported increases in overall domestic uranium reserves in 1976, but estimates of reserves recoverable at a cost of $10 or less per pound of U_3O_8 declined significantly owing to the effects of inflation and to reevaluation of data for certain deposits. There were 526 properties having reserves at $10 per pound of U_3O_8 and 1,801 properties having reserves at $30.

ERDA continued to expand its NURE program to assess the potential uranium resources of the United States, including Alaska, by 1981.[3] Nearly 80,000 miles of aerial radiometric reconnaissance surveys were flown in 1976 using computerized, high-sensitivity, gamma-ray spectrometers and magnetic detectors. The resource program also included hydrogeochemical studies and the sampling of alluvial sediments. Participants included ERDA's national laboratories, private companies, universities, State agencies, and the U.S. Geological Survey. Data on the airborne and geochemical studies were placed on open file following completion of each survey. To meet the expanding program, NURE funds were increased from $14 million in fiscal 1975 to $21 million in fiscal 1976. NURE funds for fiscal 1977 were $50 million.

[3]Energy Research and Development Administration. Annual NURE Report 1976. GJBX - 11 (Grand Junction, Colo.), 1977, 75 pp.

Table 4.—Domestic ore reserves at various estimated costs

Cutoff costs (dollars per pound of U_3O_8)	Tons of ore (millions)		Average grade (percent)		Tons of U_3O_8	
	1975	1976	1975	1976	1975	1976
$10	156	129	0.17	0.19	270,000	250,000
$15[1]	329	305	.13	.14	430,000	410,000
$30[1]	774	786	.08	.09	640,000	680,000

[1]Includes lower cost reserves.

Source: Energy Research and Development Administration.

Table 5.—Domestic resource estimates

Cost category per pound of U_3O_8	Tons of U_3O_8		
	Probable	Possible	Speculative
$10	275,000	115,000	100,000
$15[1]	585,000	490,000	190,000
$30[1]	1,090,000	1,120,000	480,000

[1]Includes lower cost resources.

Source: Energy Research and Development Administration.

DOMESTIC PRODUCTION

Mine.—Gross uranium ore output was 25% higher than that of 1975, but the average ore grade and mill recovery were lower. Domestic ores mined in 1976 graded an average of 0.15% U_3O_8, down from 0.16% in 1975 and 0.17% in 1974. ERDA data indicated production, by State, as follows:

State	Mine production[1]	
	Ore (thousand tons)	U_3O_8 content (tons)
New Mexico	3,401	6,500
Wyoming	3,315	4,400
Other[2]	2,482	3,100
Total	9,198	14,000

[1]Does not include output of approximately 200 tons of U_3O_8 from mine waters, leaching operations, and recovery from phosphate rock processing.
[2]Colorado, Texas, Utah, and Washington; combined to avoid disclosing individual company confidential data.

About 48% of the total production of 14,000 tons of U_3O_8 was from open pit mines, 48% from underground mines, and 4% from other sources. There were 209 underground mines, 44 open pits, and 28 miscellaneous sources in 1976, compared with 121 underground mines, 23 open pits, and 25 miscellaneous operations in 1975.

In 1976, many new mines, mainly in New Mexico and Wyoming, were either brought into production, under development, or planned. The Johnny M mine in New Mexico, a joint venture of Ranchers Exploration & Development Corp. (RED) and HNG Oil Co., began production from Section 7 in late 1976, after being delayed almost a year by startup problems. Full production of about 600 tons of ore per day is anticipated in early 1977 following development of the Section 18 ore body. RED and Chaco Energy Co. were developing the Hope mine near Grants, N. Mex. for ore production of 6,000 tons per month in1977. A 465-foot shaft was completed in September. Ore reserves, estimated at 224,000 tons containing 826,000 pounds of recoverable U_3O_8 were adequate for about a 3-year operation.

Phillips Petroleum Co. announced plans for the development of its Nose Rock deposit near Crownpoint, N. Mex.[4] Plans called for the sinking of four 3,400-foot shafts, two for production and two for ventilation, be-

[4]Phillips Petroleum Co. 1976 Annual Report. P. 16.

ginning in 1977. Production of about 3,000 tons of ore per day was expected in the early 1980's. Mill construction was planned for 1978. The deposit was estimated to contain reserves of about 25 million pounds U_3O_8.

The L-Bar mine and mill complex in the Laguna District, New Mexico, jointly owned by Sohio Petroleum Co. and Reserve Oil & Minerals Corp. (ROM), began uranium production in August. The only operating mine of the complex, the J. J. Number One mine, was expected to attain full production of 1,500 tons per day by mid-1977. Aggregate reserves in three deposits on the property totaled 17.4 million pounds of U_3O_8. The mill, which was completed by Fluor Utah, Inc. in July, was approaching rated design capacity, 1,600 tons per day, at yearend. Much of the ore being milled, however, was from the nearby, recently opened St. Anthony open pit mine of United Nuclear Corp. (UNC). UNC planned a yearly production of 500,000 pounds of U_3O_8. Recent drilling and mine development indicated that the St. Anthony mine's U_3O_8 reserves were substantially higher than the 7.9 million pounds initially thought to be present.

UNC continued development at its largest ore-producing mine located near Church Rock, N. Mex. A second 1,760-foot production shaft was completed in late 1976. Annual production of the mine was anticipated to be about 3 million pounds of U_3O_8 when the new shaft is operational in 1977. Construction of a 3,000-ton-per-day mill was on schedule, and the mill was expected to be completed in June 1977.

Gulf Mineral Resources Co. (GMR), a division of Gulf Oil Corp., continued development on the largest and deepest uranium mine in the United States, near Mount Taylor in New Mexico. The ore body, which lies at a depth of 3,500 feet, was estimated to have reserves exceeding 100 million pounds of U_3O_8. At yearend, both the 24-foot main shaft and the 14-foot service shaft were sunk to a depth of about 1,000 feet. Shaft sinking was expected to be completed in 1979, with commercial production scheduled for 1981.

Kerr McGee Corp. (KMC) continued uranium ore production from seven mines in the Ambrosia Lake region near Grants, N. Mex., and from its new Church Rock No. 1 mine, which was expected to attain full capacity in 1977. KMC planned three additional mines in New Mexico: A second mine at Church Rock and mines at Roca Honda in eastern Ambrosia Lake and at Rio Puerco between Grants and Albuquerque. The Rio Puerco mine was expected to begin production in early 1977.

The Section 21 (Ruby) mine at Smith Lake, N. Mex., operated by Western Nuclear, Inc. (WNI), began ore production in mid-1976 at a rate of about 15,000 tons per month. The ore was being toll-milled milled at Ambrosia Lake. WNI, which has additional reserves at Smith Lake, was planning a second mine in the area.

Mining operations at Homestake Mining Co.'s (HMC) F-33 mine near Grants were terminated late in 1976. To meet its contract commitments, HMC was increasing production at the four United Nuclear-Homestake Partners (UNHP) mines in the Grants area and planned to bring onstream a fifth UNHP mine in the latter half of 1977. Production from the new mine was expected to be about 200,000 pounds of U_3O_8 per year.

In Colorado, HMC continued development of the Pitch open pit mine near Gunnison. Production, expected in 1977, was to be toll-processed through the UNHP mill in New Mexico prior to the startup of the Pitch mill, scheduled for operation in 1979. Plans called for mine production of 150,000 tons of ore per year with a mill output of 600,000 pounds of U_3O_8 yearly. Reserves were estimated to exceed 10 million pounds of U_3O_8.

In December, Utah International Inc. (UI), a large producer of uranium in Wyoming, merged with General Electric Co. (GE), with GE as the surviving company. UI's uranium operations were transferred to a new wholly owned subsidiary, the Lucky Mc Uranium Corp. Under terms of the merger, Lucky Mc will not be able to sell uranium to GE until the year 2000.

Lucky Mc planned to develop nine uranium pits on its Green Mountain uranium property, located 15 miles southeast of Jeffrey City, Wyo. The company began stripping operations and mine construction in 1976. Development of the pits, which involves the removal of about 100 million cubic yards of overburden, was not expected to be completed until the mid-1980's. Mineral Exploration Co., a subsidiary of Union Oil Co., and Silver Bell Industries planned a mining operation to produce about 15 million pounds of U_3O_8 from a property near Rawlins, Wyo.[5] Construction of a $45 million mine-mill complex was expected to begin in 1977 with a 3,000-ton-per-day mill scheduled for startup in late 1978.

[5]Mining Journal (London). Uranium Mine Near Rawlins. V. 287, No. 7367, Oct. 29, 1976, p. 342.

Rocky Mountain Energy Co., a joint venture of Union Pacific Corp. and Mono Power Co., was constructing a $50 million mine-mill complex at Bear Creek, 65 miles northeast of Casper, Wyo. Construction of a 1,000-ton-per-day mill began in 1976, and the mill was expected onstream in late 1977. A 12-year operation was envisioned.

The Cleveland-Cliffs Iron Co., Getty Oil Co., Skelly Oil Co., and Nuclear Resources Inc., a unit of Commonwealth Edison Co. of Chicago, were planning to develop reserves containing 12 million to 18 million pounds of U_3O_8 in the North Butte area of the Powder River basin in Wyoming. A full-scale mining and milling operation was envisioned in 1982.[6]

KMC signed a uranium sales contract with Public Service Electric and Gas Co. of New Jersey, calling for the delivery of 20 million pounds of uranium between 1980 and 1995.[7] The uranium is scheduled to be mined from KMC's reserves in the South Powder River basin in Wyoming. The project, as planned, required the opening of three underground and several open pit mines and construction of a uranium mill. KMC planned to start production from the Bill Smith mine, its first mine in the basin, in 1977. The production shaft and haulage development of the Bill Smith mine were nearly complete at yearend.

The Morton Ranch property in Wyoming, a joint venture of the Tennessee Valley Authority and UNC, was expected to begin production in 1977. Stripping operations on a 32-acre area began in December. Startup of a 1,000-ton-per-day mill was scheduled for 1979. Ore reserves containing 11.4 million pounds of U_3O_8, were expected to be exhausted in about 10 years.

WNI, which received approval in October from the U.S. Department of the Interior, planned to proceed with its $50 million Sherwood uranium project on the Spokane Indian Reservation near Wellpinit, Wash. Development of the mine and construction of a 2,000-ton-per-day mill were to begin in January 1977, with completion scheduled for mid-1978. Reserves were estimated to be about 12.5 million pounds of U_3O_8.

Standard Oil of California planned to begin construction in 1977 on a $40 million mining and milling operation in south Texas near Panna Maria, where the company has reserves of about 5.5 million pounds of U_3O_8. Open pit mining and ore processing were expected in 1979; eventual capacity was anticipated at 2,000 tons of ore per day.[8]

The establishment of uranium-ore-buying stations in Colorado and Utah by private companies resulted in the opening of many small independent mines. GE was planning to increase ore buying at its Naturita, Colo., buying station from less than 10,000 tons per month in 1976 to 20,000 tons per month in 1977. Energy Fuels Ltd. (EFL) was establishing ore-buying stations at Hanksville and Blanding in southern Utah. In December, EFL owned, leased, or held production rights of 30 small, active mines. The company, which anticipates bringing in about 1 million pounds of U_3O_8 in ore per year, was studying proposals on whether or not to establish mills near the buying sites.

UOCO, Inc., established a buying station in Salt Lake City in July and was buying ore from independent and widely scattered producers. Plans called for the arranging of toll milling and supplying of yellowcake to utility clients.

Solution Mining.—Niagara Mohawk Utilities (NMU) and U.S. Steel Corp. (USS) bought out the interest of Atlantic Richfield Co. (ARCO) and Dalco Oil Co. in two in situ producing properties in the Clay-West uranium field in Live Oak County, Tex. The sale of ARCO's interest in the uranium properties reportedly was to help lessen antitrust objections to the planned acquisition of The Anaconda Company by ARCO. Production capacities of the two properties were rated at 150,000 and 250,000 pounds of U_3O_8 per year in 1976. Facilities at both properties were undergoing expansion and were expected to have capacities of 500,000 and 1 million pounds of U_3O_8 by 1978.

Intercontinental Energy Corp. (IEC) planned to start production at a 150,000-pound-per-year in situ facility on its Pawnee and Sparkman properties in Bee and Live Oak Counties, Tex., in early 1977 to fulfill a uranium contract with Virginia Electric Power Co. IEC concluded another sales contract in December that will require the startup in early 1978 of a 300,000-pound-U_3O_8-per-year in situ leaching operation on its Zamzow site, also in Live Oak County. The Zamzow site was reported to have uranium reserves of 1.3 million pounds of U_3O_8.

Wyoming Minerals Corp. (WMC), which has several in situ operations, began production at its Bruni, Tex., site (250,000

[6]American Metal Market. Cleveland-Cliffs Reports Group Plans To Develop Uranium Site. V. 83, No. 178, Sept. 10, 1976, p. 8.

[7]The Mining Record. Largest Uranium Contract in Kerr-McGee's History Signed. V. 87, No. 25, June 16, 1976, p. 4.

[8]American Metal Market. Socal Investing $40 Million in Texas Uranium. V. 82, No. 196, Oct. 6, 1976, p. 9.

pounds per year capacity) in 1976 after startup problems were resolved. WMC was also planning to bring its Lamprecht lease in Texas into production in 1977 at a rate of 500,000 pounds of U_3O_8 per year. In Wyoming, WMC was constructing a solution-mining facility at its Irigaray property, 40 miles southeast of Buffalo. Plans called for a facility able to produce 500,000 pounds of U_3O_8 per year, to be operational in early 1978.

Other companies operating pilot solution mining operations in 1976 in Texas and Wyoming included KMC, Union Carbide Corp. (UCC), and Mobil Oil Co. Mobil's efforts in Webb County, Tex., reportedly may result in the country's largest in situ leaching operation.

Byproduct Uranium.—About 200 tons of byproduct uranium was produced in 1976 from mine waters, percolation leaching of ore in piles or vats, and wet-process phosphoric acid. Production of uranium from mine waters accounted for about half of the byproduct total. The only major heap-leaching operation in 1976 was a short campaign at UCC's Maybell, Colo., site.

RED acquired about 2 million tons of mill tailings at Naturita and Durango, Colo., from Foote Mineral Co. for solution recovery of uranium.[9] Tests indicated that 1.7 million pounds of U_3O_8, or about half of the uranium content, as well as substantial quantities of vanadium, were recoverable by acid leaching in impervious earthen tanks.

WMC and Kennecott Copper Corp. (KCC) were planning to construct a $6 million commercial facility to recover uranium from copper dump leach solution at KCC's Bingham Canyon, Utah, copper mine.[10] The installation will comprise two units, each processing 3,350 gallons of solution per minute through a continuous-ion-exchange loop. Production of 143,000 pounds of U_3O_8 per year is envisioned beginning in late 1977.

Production of uranium from wet-process phosphoric acid, although small in 1976, was expected to increase rapidly in the next few years and was projected to account for about 5% of domestic production in 1979.[11] The Uranium Recovery Corp. (URC), a subsidiary of UNC, was expected to begin commercial recovery of uranium in the latter half of 1977 at the W. R. Grace & Co. (WRG) phosphoric acid facility near Barstow, Fla. Startup of the uranium recovery module was delayed for more than a year owing to testing additional equipment and making process modifications. URC was planning to construct three additional modules beginning in 1977. When these four units are operational, URC will have the capacity to produce 1.3 million pounds of U_3O_8 per year.

Freeport Minerals Co. planned to construct a $32 million facility for the extraction of uranium at its wet-process phosphoric acid plant at Uncle Sam, La. The facility, which has a design capacity to produce 690,000 pounds of U_3O_8 per year, was expected to be ready for initial production in late 1978.

Gulf Oil and Minerals Corp. and WMC continued with pilot programs to recover uranium from wet-process phosphoric acid operations. Late in the year WMC announced that it was planning to build a 400,000-pound-per-year uranium recovery plant at the Farmland Industries Corp.'s phosphoric acid production facility near Barstow, Fla. Startup was expected in 1978 with commercial operation in 1979.

Mill.—Output of U_3O_8 in concentrate was 12,700 tons, about 10% higher than in 1975, owing mainly to a 19% increase in mill throughput. The mill feed grade continued to drop, averaging 0.154% U_3O_8 in 1976, down from 0.164% in 1975 and 0.174% in 1974. Sixteen conventional mills, one more than in 1975, plus two additional processing plants were operating at the end of 1976. The 16 mills operated at the highest average rate per mill ever attained (1,500 tons of ore per day), and the total tons of ore processed (8.9 million) exceeded that of the record years of 1960 and 1961 when more than 25 mills were processing ore. The mills operated at about 77% of capacity, and mill recovery decreased marginally, averaging slightly less than 93%. At yearend, total operable milling capacity was 31,160 tons of ore per day, an increase of 2,710 tons from 1975.

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[9]The Mining Record. Ranchers Exploration Acquires Colorado Uranium Mill Tailings. V. 87, No. 44, Oct. 27, 1976, p. 2.

[10]Salt Lake Tribune. New Facility To Extract Uranium. V. 214, No. 19, Nov. 12, 1976, Sec. B, p. 12.

[11]Facer, J. F., Jr. Production Statistics. Pres. at the Uranium Industry Seminar, Energy Research and Development Administation, Oct. 19-20,1976, 10 pp. Available from Grand Junction (Colo.) Office, Energy Research and Development Administration.

Table 6.—Domestic uranium mill statistics in 1976

(Short tons of U_3O_8 unless otherwise specified)

Operating mills, yearend __ number	[1]18
Average daily milling rate __ tons of ore	24,000
Mill receipts, content of ore	13,800
Millfeed:	
Content of ore	13,700
Other[2]	200
Total	13,900
Recovery rate __ percent	93
Production	12,700
Shipments	12,900
Stocks:	
Content of ore, Jan. 1, 1976	200
Content of ore, Dec. 31, 1976	300
Concentrate, Jan. 1, 1976	2,700
Concentrate, Dec. 31, 1976	2,500
In process:	
Concentrate, Jan. 1, 1976	400
Concentrate, Dec. 31, 1976	600

[1]Consists of 16 conventional mills plus 2 additional processing plants.
[2]Concentrate from leaching operations, mine waters, refinery residues, recycled tailings, and cleanup.

Source: Energy Research and Development Administration.

Table 7.—Operating domestic uranium milling and ore processing companies and capacities in 1976

Company	Plant location	Nominal capacity (tons of ore per day)
The Anaconda Company	Grants, N. Mex	3,000
Atlas Corp	Moab, Utah	1,100
Conoco-Pioneer	Falls City, Tex	1,750
Cotter Corp	Canon City, Colo	450
Dawn Mining Company	Ford, Wash	400
Exxon Co.,USA	Powder River Basin, Wyo	3,000
Federal-American Partners	Gas Hills, Wyo	950
Kerr-McGee Nuclear Corp	Grants, N. Mex	7,000
Lucky Mc Uranium Corp	Gas Hills, Wyo	1,650
Do	Shirley Basin, Wyo	1,800
Rio Algom Corp	La Sal, Utah	700
Sohio-Reserve Oil	Cebolleta, N. Mex	1,660
Union-Carbide Corp	Uravan, Colo	1,300
Do	Gas Hills, Wyo	1,200
United Nuclear-Homestake Partners	Grants, N. Mex	3,500
United States Steel Corp	George West, Tex	(1)
U.S. Steel-Niagara Mohawk	do	(1)
Western Nuclear, Inc	Jeffrey City, Wyo	1,700
Total[2]		31,160

[1]Uranium obtained by solution mining.
[2]Includes only solution-mining operations producing dry, marketable, uranium concentrate.

Source: Energy Research and Development Administration.

The Anaconda Company planned a $20 million expansion of its Blue Water uranium mill near Grants, N. Mex. The expansion, scheduled for completion in late 1977, would increase mill capacity from 3,000 to 6,000 tons per day and was expected to allow the processing of lower grade ores without affecting uranium output. Additional ore requirements were expected to come from the Jackpile-Pugate open pit mine at Laguna.

Getty Oil Co. and Skelly Oil Co. planned to reopen the Petrotomics mill in the Shirley Basin, Wyo., in late 1977 or early 1978. The mill, which has a capacity of 1,500 tons per day, was undergoing reconditioning plus process improvements in anticipation of processing ore from Getty's UJV properties in the Shirley Basin. Overburden removal from the UJV deposit began in early 1976, and mining was scheduled to commence in 1977.

Cotter Corp., a subsidiary of Commonwealth Edison of Chicago, announced plans for a $23 million expansion of its uranium mill at Canon City, Colo.[12] The expansion, which is designed to boost milling capacity from 450 tons per day to 1,000 tons per day, was expected to require the reopening of five mines on the Colorado Plateau, as well as increased ore production from the company's Schwartzwalder mine.

Uranium Hexafluoride (UF_6).—Two commercial operations—the Allied Chemical Corp. plant at Metropolis, Ill., and the Kerr McGee Corp. (KMC) plant at Sequoyah, Okla.—produced UF_6 during 1976. The conversion capacities of the two plants were 14,000 and 5,000 tons, respectively, of uranium as UF_6. KMC's program to double conversion capacity by early 1978 was on schedule. According to ERDA, the available annual conversion capacity of 26,450 short tons of uranium after the KMC expansion will be sufficient until about 1979.

Beker Industries Corp. delayed plans to build a plant at Carlsbad, N. Mex., for the conversion of uranium to UF_6. The company was, however, continuing feasibility studies on a plant expected to cost $100 million and have a capacity of 23,500 tons of UF_6 per year.

Enriched Uranium.—ERDA reported enrichment revenues of $588 million in 1976 for separative work furnished under enrichment contracts. A total of 9.6 million separative work units (SWU)[13] was carried out for 26 domestic and 17 foreign customers. At yearend ERDA held longterm enrichment services contracts covering 329,000 electrical megawatts of nuclear power. Of the total, 208,000 megawatts represented domestic nuclear powerplants and 121,000 megawatts represented foreign plants. Throughout 1976 the transacting tails assay continued at 0.20% U-235 and operating tails at 0.25% U-235.

The ongoing ERDA Cascade Improvement Program (CIP) and Cascade Uprating Program (CUP) were expected to increase the annual SWU capacity of the Government's three enrichment plants from 17.2 million to 27.7 million by 1981. These programs, costing about $1.5 billion, were on schedule in 1976. The additional separative work gain installed in CIP at yearend was about 1.3 million SWU per year; by October 1977, the gain was expected to total about 2.5 million SWU.

ERDA obtained preliminary approval to build an additional gaseous diffusion enrichment plant at Portsmouth, Ohio. Plans called for initial production from this plant in 1984 with full production in 1986. The plant, which has an estimated cost of $4.4 billion, was expected to add 8.75 million SWU capacity to the present enrichment plant complex. The plant is anticipated to allow continued enrichment operations, to have nearly optimum nuclear fuel production economics, and to permit the offering of new enrichment services contracts.

A proposed bill, the Nuclear Fuel Assurance Act, which would allow private industry to enter the enrichment field, failed to obtain congressional approval in 1976. As a result, the plans of four private groups proposing construction of enrichment facilities were uncertain at yearend. The Goodyear Tire & Rubber Co. dropped out of Uranium Enrichment Associates (UEA), the only company completely shelving its plans, and ARCO withdrew from CENTAR Associates. CENTAR, Exxon Nuclear Co., Inc. (ENC), and Garrett Nuclear Corp., each of which has proposals for 3-million-SWU-per-year gas centrifuge enrichment plants, have delayed their programs awaiting Government action.

In March, ENC and Avco Corp. applied for a license to operate a facility to test the enrichment of uranium by laser technology. A facility to be located at Richland, Wash., was scheduled for startup in 1978. Power consumption of a commercial laser enrichment plant was anticipated to be about 20% less than that of a gas centrifuge plant, and a laser plant was expected to require about half the acreage of a gas centrifuge plant.

Fuel Fabrication.—Fuel fabrication orders continued to increase in 1976, despite deferrals and rescheduling of nuclear powerplants by electric utilities. ENC completed the doubling of fuel fabrication facilities at its Richland, Wash., plant. Babcock & Wilcox Co. won a $21 million order for 34,000 fuel pins to be used in the Fast Flux Test Facility being constructed at ERDA's Hanford, Wash., complex. The fuel, which is in addition to 18,000 pins previously supplied, was to be fabricated at the company's Parks Township, Pa., facility.

[12]Skillings' Mining Review. Cotler Awards Contract to Mountain States. V. 65, No. 52, Dec. 25, 1976, p. 20.

[13]Measure of work expended in separating a quantity of uranium (in kilograms) at a given assay into two fractions— one enriched in U_{235} to a specific grade, and the other deficient in U_{235} to a specific tailings grade.

Table 8.—Domestic nuclear fuels production facilities

Company	Location
Babcock & Wilcox Co	Apollo, Pa.
Do	Leechburg, Pa.
Do	Lynchburg, Va.
Combustion Engineering Corp	Windsor, Conn.
Do	Hematite, Mo.
Exxon Nuclear Co., Inc	Richland, Wash.
General Atomic Co	San Diego, Calif.
Do	Youngsville, N.C.
General Electric Co	San Jose and Vallecitos, Calif.
Do	Wilmington, N.C.
Kerr-McGee Corp	Cimarron, Okla.
North American Rockwell Corp., Atomics International Div.	Canoga Park, Calif.
Nuclear Fuel Services, Inc	Erwin, Tenn.
Tennessee Nuclear Specialties, Inc	Jonesboro, Tenn.
Texas Instruments, Inc	Attleboro, Mass.
United Nuclear Corp	Wood River Junction, R.I.
United States Nuclear Corp	Oak Ridge, Tenn.
Westinghouse Electric Corp	Cheswick, Pa.
Do	Columbia, S.C.
Do	Anderson, S.C.

In October, the Nuclear Regulatory Commission (NRC) reported its findings in the final environmental impact statement (EIS) on the use of recycled plutonium in light water reactors (LWR). The study indicated that the potential hazards to the public from the use of mixed-oxide fuel in LWRs was about the same as that from uranium alone.[14] An NRC decision on whether to permit wide-scale use of mixed-oxide fuel was to be based on the final generic environmental statement on mixed-oxide fuel (GESMO), expected in 1978.

Fuel Reprocessing.—Commercial fuels reprocessing continued in abeyance awaiting resolution of political and regulatory problems related to safeguards of plutonium, mixed-oxide fuel usage, and waste disposal. Nuclear Fuel Services, Inc. (NSF) announced that its West Valley, N.Y., nuclear-fuels-reprocessing plant, the only reprocessing plant ever to operate commercially in the United States, would not be renovated and reopened because of rapidly increasing costs.[15] NFS estimated that modifications to the plant required by new regulations and seismic criteria would cost $600 million, contrasted with the $15 million originally estimated in 1972 when the plant suspended operations to double capacity and improve efficiency. Disposition of about 600,000 gallons of radioactive reprocessing waste at the plant remained undetermined.

Allied General Nuclear Services Inc. (AGNS) completed the uranium separation and UF_6 facilities at its fuels-reprocessing plant at Barnwell, S.C., but was unable to proceed with design of the plutonium processing and waste solidification facilities because the standards had not been determined. Because of anticipated continuing delays in licensing, early utilization of AGNS's plant was expected to be related to implementation of an ERDA demonstration program for waste- and plutonium-processing facilities.

ENC planned a $1 billion complex at Oak Ridge, Tenn., for storing and reprocessing used nuclear fuel. The first phase of the project involved the building of a $300 million fuel storage facility that could hold fuel from 25 nuclear powerplants for 10 years; construction was proposed to begin in 1979 if NRC approval is obtained. The second phase entailed construction of a fuel-reprocessing center in the 1980's capable of reprocessing up to 2,100 tons of used fuel per year, enough to meet the needs of 40 nuclear powerplants.

A study by ERDA showed that recycling of LWR nuclear fuels has economic advantages over disposal of fuel elements after one use.[16] Other advantages of recycle were increased uranium availability and natural resource conservation.

Waste Management.—ERDA continued research on the terminal storage of high-level radioactive waste and was preparing a generic statement on the management of commercially generated radioactive waste. ERDA was expected to announce in 1978 a decision on waste forms, storage modes, and packaging criteria to be used as a basis for designing one or more terminal storage

[14]Nuclear News. NRC's Final EIS Supports Pu Recycle. V. 19, No. 13, October 1976, p. 33.
[15]Nuclear Industry. West Valley Plant Shut Down, "Impractical" to Renovate. V. 23, No. 10, October 1976, p. 25.
[16]Energy Research and Development Administration. Benefit Analysis of Reprocessing and Recycling Light Water Reactor Fuel. ERDA-76 (121), 1976, 27 pp.

facilities. Also in 1978, the Environmental Protection Agency and NRC were expected to announce general environmental standards applicable to high-level waste management and storage. As part of the management program, the United States was appraising salt deposits in several sections of the country to identify sites suitable for an ERDA underground storage pilot program, expected to be in operation by 1985. Facilities equipped to receive solidified high-level radioactive waste were to be included in the pilot underground waste disposal program.

Low-level commercial wastes were buried at six sites in the States of Kentucky, Nevada, South Carolina, Illinois, New York, and Washington in 1976. About 2 million cubic feet of waste was added to these sites in 1976, increasing the total to about 16 million cubic feet. These sites were estimated to have the capacity to handle low-level wastes until the mid-1990's. ERDA operated large land burial sites at five principal facilities for ERDA-generated waste. These sites contained about 45 million cubic feet of radioactive waste, exclusive of classified waste. About 1.3 million cubic feet was added in 1976.

CONSUMPTION AND USES

Domestic nuclear reactor orders totaled three in 1976, the lowest megawatt amount ordered since reactor units became commercially available in 1965. The three orders (3,720 megawatts), all obtained by Babcock & Wilcox Co., were reorders of reactors that were canceled in 1975.

The nuclear industry continued to encounter many environmental and regulatory problems, as well as reduced electrical load growth. As a result, utilities continued to defer, delay, or cancel nuclear reactor programs. Projections of nuclear power growth were also reduced. The number of nuclear units expected to be in commercial operation in 1985 was 178, compared with a 1975 estimate of 184.

Seven power-generating units (6,796 megawatts electric) were licensed to operate, and 10 were expected to come onstream in 1977. Domestic reactor status at yearend follows:

Status	Number of instal-lations	Capacity (megawatts electric)
Operable	[1]65	46,391
Under construction	90	95,195
Planned	82	94,878
Total[2]	237	236,464

[1]Includes two ERDA-owned plants.
[2]This compares with 238 units and 236,728 megawatts electric at yearend 1975.

About 10% of the total U.S. electrical power generation capability was nuclear based in 1976. Nuclear power supplied 191 billion net kilowatt-hours or 9.4%, of the Nation's electricity in 1976, compared with 170 billion kilowatt-hours or 8.9%, in 1975. According to an Atomic Industrial Forum survey, nuclear-generated electricity based on total generating costs averaged 1.5 cents per kilowatt-hour, compared with 1.8 cents per kilowatt-hour for coal and 3.5 cents per kilowatt-hour for oil.

An ERDA survey of uranium producers, utility companies, and reactor manufacturers indicated that uranium supply arrangements for planned U.S. nuclear fuel capacity improved considerably in 1976.[17] Domestic uranium-buying activity reached its highest level, resulting in additional procurement of 83,400 tons of U_3O_8 in concentrate. This total exceeded the previous high of 45,800 tons in 1973 and was over 5 times higher than the 16,200 tons added in 1975. Buyers were becoming directly involved in U_3O_8 production to obtain their fuel supplies. Twenty-five utilities were participating in uranium raw materials activities in one stage or another. About half of additional 1976 supply was scheduled to come from mine production controlled by uranium buyers.

Table 9.—Current and projected domestic U_3O_8 demand[1]

(Short tons)

Year	Demand	
	Annual	Cumulative
1976	10,700	10,700
1977	12,300	23,000
1978	19,800	42,800
1979	24,400	67,200
1980	28,600	95,800
1985	39,900	280,900
1990	45,100	499,300

[1]Feed materials required for enrichment services. Enrichment tails assay 0.20% to Oct. 1, 1980, 0.25% thereafter; no recycle.

Source: Energy Research and Development Administration.

Table 10.—Current and projected domestic commercial uranium delivery commitments

(Short tons of U_3O_8)

Year	Commitments[1]	
	Annual	Cumulative
1966-75	--	80,000
1976	13,800	93,800
1977	15,900	109,700
1978	17,900	127,600
1979	18,400	146,000
1980	20,400	166,400
1981	19,000	185,400

[1]In the post-1981 period, through 1995, an additional 103,800 tons have been committed. In addition, 13,500 tons have been committed to foreign buyers, of which 7,400 tons were delivered prior to 1976.

Source: Energy Research and Development Administration.

Table 11.—Uranium fuel supply arrangements for first cores and reloads[1]

(Percent of generating capacity covered)

Source of supply	First core	Reloads[2]											
		1	2	3	4	5	6	7	8	9	10	11	12
Primary producers	46	48	42	39	34	31	26	23	20	18	17	13	12
Reactor manufacturers	15	13	10	7	6	3	3	2	1	1	--	--	--
Imports	10	5	5	3	4	5	4	3	3	4	5	5	3
Total uranium supply arrangements completed	71	66	57	49	44	39	33	28	24	23	22	18	15
Number of uranium supply arrangements	29	34	43	51	56	61	67	72	76	77	78	82	85

[1]As of yearend 1976. Includes reactors under construction and ordered.
[2]Refueling estimated on annual basis.

Source: Energy Research and Development Administration.

STOCKS

Uranium concentrate stocks held by the producers or by milling companies were reduced during 1976, whereas those held by the consuming industry increased by 3,200 tons of U_3O_8, as indicated in the following data provided by ERDA (in tons of U_3O_8):

	Jan. 1, 1976	Dec. 31, 1976
In ore at mills	200	300
In process at mills	400	600
In concentrate at mills	2,700	2,500
In concentrate held by utility companies, reactor manufacturers, and agents (including equivalent U_3O_8 in UF_6)	22,600	25,800
Total	25,900	29,200

[17]Energy Research and Development Administration. Survey of United States Uranium Marketing Activity. ERDA 7-46, April 1976. 28 pp.

A 3,500-ton inventory of foreign U_3O_8 was also reported at yearend 1976, compared with 1,100 tons one year earlier. Overall, domestic stocks were an estimated 32,700 tons of U_3O_8, up 5,700 tons from 1975.

The stockpile of depleted uranium continued to grow as a result of large-scale enrichment services provided for domestic and foreign customers. The ERDA tailings stockpile contained about 235,000 tons of uranium in the form of UF_6 at yearend 1976.

PRICES

The price for spot sales and future deliveries of U_3O_8 in concentrate continued to rise during 1976. The strong sellers' market that developed in 1974 continued to be reflected in newly negotiated 1976 contracts, many of which called for prepayments, price adjustments, or payments based on prices prevailing at the time of delivery. According to the Nuclear Exchange Corp. (Nuexco), the spot bid price increased from \$35 per pound of U_3O_8 for delivery in January to \$41 at yearend. During this period, the bid price for delivery in 1980 increased from \$47.35 to \$53.85.[18]

An ERDA survey indicated significantly lower average U_3O_8 prices paid by reactor manufacturer and utility companies having long-term contracts.[19] According to the survey, contract prices representing 91% of commitments ranged from \$6 to \$43 per pound of U_3O_8, averaging \$16.10. In 1975 the average price per pound of U_3O_8 was \$10.50. An average price of \$18 per pound of U_3O_8 was indicated by the survey in 1980.

Uranium ore was purchased at the GE ore-buying station at Naturita, Colo., for 95% of one-half the listed spot price per pound of contained U_3O_8. A minimum of 2 pounds of U_3O_8 per ton of ore was required for purchase.

The costs for enrichment services continued to rise because of increasing operating expenses at ERDA's three enrichment facilities. In April, fixed-commitment contract holders were paying \$59.05 per SWU, an increase of \$5.70. Customers with requirements-type contracts began paying \$67.25 per SWU in August. The previous price was \$60.95 per SWU.

Depleted uranium metal in 300-pound ingots (Derby metal) was priced at \$2 per pound.

FOREIGN TRADE

Uranium imports were largely in the form of U_3O_8 concentrate and UF_6. Most imports were for enrichment services rather than for domestic consumption. Since imports are not differentiated in official statistics, precise figures on uranium imports for domestic consumption are not available. According to data compiled by ERDA, uranium imports amounted to 2,900 tons of U_3O_8 in 1976, 1,800 tons more than in 1975. In 1976, an additional 1,800 tons of foreign U_3O_8 was contracted for by the domestic industry bringing the total foreign procurement for future delivery to 43,200 tons.

Restrictions on the enrichment of foreign uranium for domestic use continued to yearend 1976. Beginning in 1977, the enrichment of up to 10% of a utility's uranium requirements could come from foreign sources. The allowable percentage was to be

[18]Nuclear Exchange Corp. Nuexco Monthly Report to the Nuclear Industry. No. 101, Dec. 31, 1976, p. 3.
[19]Page 6 of work cited in footnote 17.

Table 12.—U.S. uranium import and export commitments

(Short tons of U_3O_8)

Year	Exports		Imports	
	Annual	Cumulative	Annual	Cumulative
1976	600	600	2,900	2,900
1977	2,100	2,700	4,000	6,900
1978	900	3,600	2,600	9,500
1979	900	4,500	3,300	12,800
1980	[1]1,600	6,100	4,200	17,000
1981-85	--	6,100	19,800	36,800
1986-90	--	6,100	9,300	46,100

[1]1980 and later.

Source: Energy Research and Development Administration.

Table 13.—Foreign trade in uranium, uranium-bearing materials, and other nuclear materials, by principal country

Product	1975		1976		Principal sources and destinations, 1976
	Quantity	Value	Quantity	Value	
EXPORTS					
Uranium:					
Ores and concentrates, U_3O_8 content pounds	122,663	$1,839,953	1,495,130	$24,431,936	United Kingdom 1,013,403; Canada 312,121; Italy 169,606.
Compounds do	3,837,266	52,039,852	369,036	7,232,389	United Kingdom 308,038; West Germany 43,582; Netherlands 13,659; Canada 2,104.
Metal including alloys[1] do	14,840	203,415	7,108	145,758	Italy 2,355; Japan 1,686; Canada 1,661.
Isotopes (stable) and their compounds	NA	2,679,033	NA	2,102,844	West Germany $370,049; Netherlands $307,895; United Kingdom $299,209; Canada $247,075; Switzerland $190,734; Belgium-Luxembourg $119,754.
Radioactive materials:					
Radioisotopes, elements, and compounds[2] thousand curies	37,850,386	20,087,647	31,649,488	25,905,396	West Germany 8,800,531; Canada 8,782,207; Japan 4,997,834; Switzerland 2,363,785; Australia 1,309,505; Brazil 1,262,467; Mexico 859,033; United Kingdom 630,786; France 366,469.
Special nuclear materials[3]	NA	236,848,895	NA	426,423,004	West Germany $104,811,268; Japan $100,454,271; France $69,670,862; Switzerland $32,883,781; Korea $26,473,117; Sweden $22,972,185; Taiwan $21,334,958; United Kingdom $19,086,822; Italy $9,549,488; Spain $5,512,815; Belgium-Luxembourg $4,245,015; Netherlands $3,927,950; Canada $2,567,469; India $2,520,559.
IMPORTS					
Uranium:					
Oxide (U_3O_8) pounds	2,451,538	24,480,662	11,074,298	203,926,307	Canada 7,201,046; France 3,531,208; United Kingdom 144,860.
Other compounds do	19,226,578	161,507,129	33,876,908	441,603,275	France 15,034,192; Canada 9,527,788; United Kingdom 9,106,467.
Isotopes (stable) and their compounds	NA	957,175	NA	1,067,344	Canada $517,806; U.S.S.R. $288,071; United Kingdom $127,112; West Germany $51,691.
Radioactive materials:					
Radioisotopes, elements, and compounds[4] thousand curies	35,346,036	8,296,907	60,302,966	12,200,050	Canada 31,430,793; Switzerland 23,086,308; France 4,427,692; United Kingdom 506,911; Sweden 408,161; U.S.S.R. 263,062.

NA Not available.
[1]Includes thorium.
[2]Includes carbon-14 and cobalt-60.
[3]Includes plutonium, uranium-233, and enriched uranium.
[4]Includes cobalt-60.

increased each year until 1984, when 100% of a utility's uranium requirements could come from imported material. Commitments by domestic uranium producers to sell uranium to foreign buyers increased by 2,600 tons of U_3O_8 during 1976, raising the total forward commitment to 5,500 tons. ERDA reported that 600 tons of U_3O_8 was delivered to foreign buyers in 1976.

The worldwide spread of nuclear technology, relative to the prevention of proliferation of nuclear weapons, gained increasing attention in 1976. Bills were introduced in Congress that would limit or halt exports of U.S.-enriched uranium and technology and would restrict other countries.

In October, the President called for a 3-year international moratorium on exports of reprocessing and enrichment facilities to prevent nuclear proliferation. There were objections by Western European countries, Japan, and many developing countries, primarily because they lack suitable energy alternatives and view nuclear power and the breeder reactor as their future sources of energy. Legislative action on the proliferation policy was expected in 1977.

WORLD REVIEW

Uranium exploration continued to expand on a worldwide scale. Many countries had some form of exploration program underway or planned in 1976. Few major deposits were discovered; however, uranium reserves increased significantly. Estimated world uranium reserves to $30 per pound of U_3O_8 were about 2.4 million tons of U_3O_8. An additional 2.1 million tons of U_3O_8 of resources was indicated.

Forecasts for nuclear power growth outside the United States continued to decline, mainly because of 2 years of poor economic growth and diminishing growth rates for electricity consumption. Public opposition was also rising. Projections by ERDA indicated that the world's nuclear generating capacity was expected to grow from the 1976 level of about 86 gigawatts to over 1,500 gigawatts by the year 2000. 2000.[20] Foreign growth was expected to occur largely in Western Europe and Japan to the year 2000; significant growth in the developing countries was anticipated after 1990. At yearend, the European Economic Community (EEC) Commission projected that installed nuclear capacity by 1985 in EEC countries would be about 125 gigawatts, about 50 gigawatts less than projected 2 years earlier.

Despite lower forecasts, nuclear power continued to be the fastest growing electrical energy form, and worldwide, operable capacity increased from 75,103 megawatts in 1975 to 86,657 megawatts in 1976.

According to yearend data compiled by the American Nuclear Society, 111 plants

Table 14.—World uranium resources[1]

(Thousand tons of U_3O_8)

Country	Reasonably assured[2]	Estimated additional[2]
North America:		
United States	680	1,090
Canada	225	510
Mexico	8	--
Denmark (Greenland)	8	13
Total	921	1,613
Africa:		
South and South-West Africa	359	96
Niger	65	39
Algeria	36	--
Gabon	26	13
Central African Empire	10	10
Zaire	2	2
Total	498	160
Europe:		
Sweden	390	--
France	72	52
Spain	30	56
Yugoslavia	9	20
Portugal	9	--
Finland	3	--
Germany, West	1	5
Italy	2	1
United Kingdom	2	5
Total	518	139
Australia	430	100
Asia:		
India	38	30
Japan	10	--
Korea, Republic of	3	--
Turkey	4	1
Total	55	31
South America:		
Argentina	27	51
Brazil	18	11
Total	45	62
Total (rounded)	2,400	2,100

[1]Excludes central economy countries.
[2]At $30 per pound of U_3O_8.

Sources: ERDA, International Atomic Energy Agency, and Organization for Economic Co-operation and Development Nuclear Energy Agency.

[20]Hanrahan, E. J., R. H. Williamson, and R. W. Bown. World Requirements and Supply of Uranium. Pres. at the Atomic Industrial Forum International Conference on Uranium, Geneva, Switzerland, Sept. 14, 1976, 21 pp. Available from Energy Research and Development Administration, Washington, D.C.

outside the United States were operable in 18 countries and 187 nuclear units were planned in 30 countries. This compares with 104 plants operable in 18 countries and 168 units planned in 29 countries at the end of 1975. Most of the planned units were scheduled for completion by 1985. Tables 15 and 16 indicate the foreign nations having operable or planned nuclear powerplants at the end of 1976.

Table 15.—Operable foreign nuclear powerplants in 1976

Country	Number of units	Net capacity (megawatts electric)
Argentina	1	319
Belgium	3	1,650
Bulgaria	2	880
Canada	6	2,512
Czechoslovakia	1	110
France	10	2,818
Germany, East	3	950
Germany, West	9	5,334
India	3	602
Italy	3	547
Japan	13	7,174
Netherlands	2	532
Pakistan	1	125
Spain	3	1,073
Sweden	5	3,169
Switzerland	3	1,006
United Kingdom	31	6,830
U.S.S.R	12	4,635
Total	111	40,266

Source: American Nuclear Society.

Table 16.—Scheduled foreign nuclear powerplants[1]

Country	Number of units	Capacity (megawatts electric)
Argentina	1	600
Austria	1	692
Belgium	4	3,835
Brazil	3	3,116
Bulgaria	2	880
Canada	14	9,324
Czechoslovakia	4	1,760
Finland	4	2,160
France	34	32,658
Germany, East	4	1,760
Germany, West	18	18,995
Hungary	4	1,760
India	5	1,082
Iran	4	4,200
Italy	6	4,748
Japan	14	10,528
Korea, Republic of	3	1,798
Luxembourg	1	1,300
Mexico	2	1,308
Philippines	2	1,252
Poland	1	440
Romania	1	440
South Africa, Republic of	2	1,844
Spain	13	12,081
Sweden	7	6,240
Switzerland	5	4,840
Taiwan	6	4,924
United Kingdom	8	4,950
U.S.S.R	13	9,730
Yugoslavia	1	615
Total	187	149,860

[1]Under construction or ordered as of Dec. 31, 1976.

Source: American Nuclear Society.

Western Europe and Japan continued to rely on enrichment services from the United States, but the Europeans planned to become self-sufficient in enrichment in the mid-1980's. Urenco Ltd., a tripartite organization of the Netherlands, the United Kingdom, and West Germany, was commissioning commercial gas-centrifuge enrichment plants at Almelo, Netherlands, and at Capenhurst, United Kingdom. The first sections of both full-scale production plants, having capacities of 200,000 SWU, were completed in late 1976. Plans called for Urenco capacity to reach 2 million SWU annually by 1982 and 10 million SWU annually by 1985. Deliveries of enriched uranium reportedly were made from Urenco's two 50,000-SWU-per-year-capacity pilot enrichment plants. Eurodif, a five-nation consortium comprising France, Belgium, Iran, Italy, and Spain, continued construction of a gaseous diffusion enrichment plant at Tricastin, France. The plant was expected to have a 2.3-million-SWU capacity by 1979, increasing to 10.8 million SWU per year by 1982. Another group, Coredif, a joint venture of the Eurodif partners, was planning to construct a similar-sized, diffusion-enrichment facility, to meet projected shortfalls in enrichment capacity in the mid-1980's.[21] Although the site for the Coredif plant was undecided, the first stage, having a 5-million-SWU-per-year capacity, was anticipated to be onstream in 1985 with full production in 1988.

Other countries were also building or planning to build enrichment pilot plants. Japan's Power Reactor and Nuclear Fuel Development Corp. (PRF) was proceeding with the construction and operation of a 50,000-SWU-capacity pilot centrifuge enrichment plant. PRF proposed building a 500,000-SWU demonstration plant by 1984, followed by a 1-million-SWU-capacity commercial plant by 1988, and increasing overall capacity to 4 million SWU by 1995. The Uranium Enrichment Corp. (UCOR) of the Republic of South Africa completed its pilot plant at Valindaba and tested the feasibility of its stationary-wall centrifuge technique. UCOR planned to proceed with a commercial-scale plant, estimated to have a

[21]Nuclear News. Nuclear News Briefs. V. 19, No. 13, October 1976, p. 97.

5-million-SWU annual capacity. Initial production was planned for 1984, followed by full output in 1986. West Germany's plans to build a 180,000-SWU-per-year demonstration enrichment plant in Brazil using an advanced nozzle-enrichment method were delayed awaiting clarification of the West German Government's proliferation policy. A large-scale commercial plant with a capacity of 1 to 2 million SWU per year was envisioned if the program is carried out.

Progress continued toward solving problems in the back end of the fuel cycle. Research programs dealing with spent fuel storage, reprocessing, and waste management continued in those countries having large nuclear programs. British Nuclear Fuels Ltd. (BNFL) planned to spend $1.8 billion over the next 5 years at the Windscale site to provide greatly increased reprocessing and waste treatment capacity. A 1,300-ton thermal oxide reprocessing plant was proposed, based mainly on the need to reprocess fuel from the United Kingdom's Magnox program and on fuel-reprocessing contracts from Japanese utilities.

La Compagnie General des Matieres Nucleaires (Cogema), the French Government fuels-reprocessing company, also planned to greatly increase reprocessing capacity. Cogema began oxide reprocessing in May at its plant at La Hague. The facility, which will primarily be devoted to the processing of imported fuels, was scheduled to have a capacity of 800 tons per year by 1980. A consortium of Japanese companies was planning to establish a fuels-reprocessing company to process all nuclear fuels used by utilities in Japan. Plans called for the establishment of a 1,500-ton-per-year facility by 1987. Most Japanese fuels were scheduled to be reprocessed by BNFL and Cogema in Europe prior to full development of the reprocessing industry in Japan. A small (40-ton-per-year) reprocessing plant owned by the Power Reactor and Nuclear Fuel Development Corp. (PNC) at Tokai Muri had difficulties in 1976 and was not expected to be commissioned until late 1977.

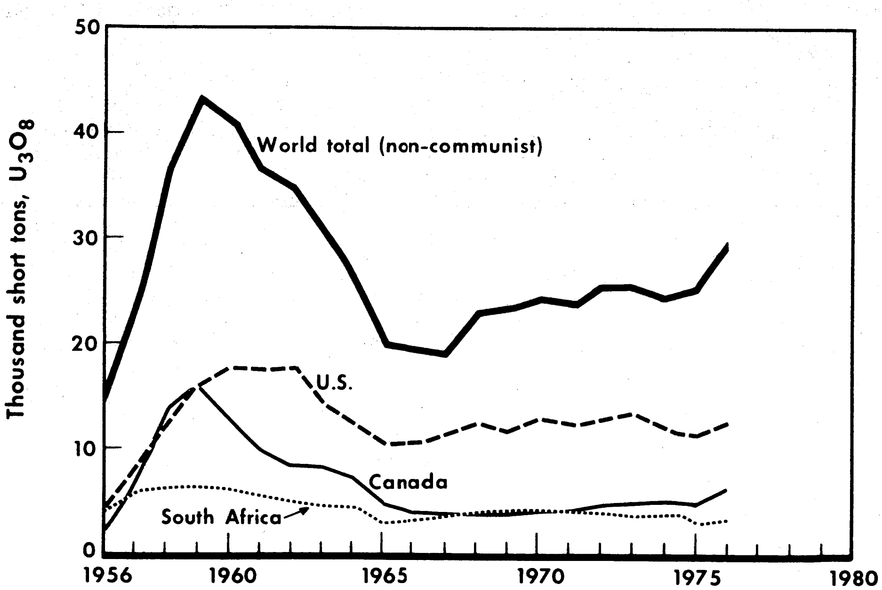

Figure 1.—World production of uranium concentrate (U_3O_8).

Table 17.—Uranium oxide (U_3O_8) concentrates: World production, by country

(Short tons)

Country[1]	1974	1975	1976[p]
Argentina	[r]42	43	[e]44
Australia	--	--	465
Canada[2]	4,795	6,083	6,678
France	[r]2,002	2,250	2,357
Gabon	1,001	1,209	1,196
Niger	[r]1,456	1,820	1,898
Portugal	[e]100	[e]110	97
South Africa, Republic of	3,525	3,234	3,587
South-West Africa, Territory of	--	--	772
Spain	[r]87	248	226
Sweden[e]	80	80	80
United States	11,528	11,600	12,700
Total	[r]24,616	26,677	30,100

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed Brazil, Czechoslovakia, Finland, East Germany, West Germany, Hungary, India, Israel, Japan, the People's Republic of China, and the U.S.S.R. are believed to have produced uranium oxide, but information is inadequate to make reliable estimates of output levels.

[2]Data represent shipments. Official production was reported as follows in short tons: 1975—[r]4,565; 1976—6,252.

Argentina.—A 600-ton-per-year uranium mine-mill complex was planned at Comision Nacional de Energia Atomica's (CNEA) uranium deposit at Sierra Pintala in Mendoza Province, 500 miles west of Buenos Aires. CNEA projected that this operation, expected to start in mid-1979, could supply the country's uranium needs for 15 years.

A new mill at Los Adobes in Cherbut Province started up in June and was expected to produce about 6 tons of yellowcake per month beginning in 1977. CNEA was expecting the country's uranium output to exceed 130 tons in 1977 as a result of the new operation; 1976 output was about 44 tons.

Australia.—Uranium exploration, after several years of intense effort, was at reduced levels in 1976, as companies waited for clarification of Government policy on production and exports. The first Fox Commission report endorsed uranium mining and milling; however, development of uranium deposits in the Northern Territories was not to be allowed until a second Fox report on the Ranger deposit was issued. An interim report released in October indicated that development might be limited in 1977.

In November the Government granted export permits for earlier uranium sales contracts for Mary Kathleen Uranium Ltd. (MKU), Queensland Mines Ltd. (QM), and the Ranger deposit of Electrolytic Zinc Co. of Australasia Ltd. and Peko-Wallsend Mines Ltd. Because production from QM or Ranger was not expected for a few years, deliveries from government stocks were to be permitted to meet early delivery commitments.

The Government was dropping out of active uranium exploration and selling its participation in uranium mining ventures. Government policy requiring 75% Australian ownership in uranium projects before production begins, however, was continued.

In June, the South Australian Government announced that a 2-year feasibility study of a proposed $1.6 billion uranium gas-centrifuge enrichment plant would be carried out. The proposed plant, which would include a hexafluoride conversion facility, was to be sited at Redcliffe near Port Augusta.

Australia's reasonably assured uranium resources recoverable at less than $15 per pound of U_3O_8 in June totaled 250,000 tons, an increase of almost 48,000 tons over the $10 reserves estimated 1 year earlier.[22] The addition was due primarily to a substantial increase in the reserves at the Jabiluka 2 deposit in the Northern Territory.

MKU resumed operations in May at the Mary Kathleen mine in Queensland producing at a rate of about 1,000-tons of U_3O_8 per year. Reserves at the mine were sufficient for about 8 years' operation. Shipments of concentrate, all for export, were delayed for much of the year owing to strikes by the transportation unions.

Western Mining Corp. Ltd. planned to build a $15 million alkali-leach pilot plant as part of the development of the Yeelirrie uranium deposit in Western Australia. Commercial development was, however, dependent on Government approval of export contracts.

[22]Australian Atomic Energy Commission. Twenty-Fourth Annual Report. 1975-76, 135 pp.

Brazil.—Empresas Nucleares Brazileiras S.A. (Nuclebras), a Government agency, spent about $20 million on uranium exploration in 1976. Extensive uranium reserves were reportedly found in Goías State near Amarinopolis, 300 miles southeast of Brasilia.[23] A new company, Nuclebras Auxiliar de Mineração (Nuclam), owned 51% by Nuclebras and 49% by West Germany's Urangesellschaft MbH, began uranium exploration programs in the States of Paraíba and Santa Catarina. This company was the first of a group of nuclear ventures to be established under a nuclear cooperation agreement signed in July 1975.

According to Nuclebras, Brazilian uranium reserves totaled about 29,000 tons of U_3O_8. The principal deposits and estimated tonnage follow:

Deposit	Tons of U_3O_8
Pocos de Caldas (Minas Gerais)	15,300
Figueira (Parana)	5,300
Quadrilatera Ferrifero (Minas Gerais)	4,500
Amarinopolis (Goias)	3,300
Campos Belos (Goias)	600
Total	29,000

Nuclebras planned a $30 million mine-mill facility at Poços de Caldas. Production was scheduled to start in 1979 at a rate of 500 tons of U_3O_8 per year.

Canada.—Uranium production, 6,252 tons of U_3O_8 in 1976, was 37% higher than in 1975. One new mine was brought into production and established producers were well advanced with expansion programs.[24]

Exploration activity continued to increase, and significant mineralization was found in several areas, most notably at Key Lake in Saskatchewan.

The Canadian Government continued its Uranium Reconnaissance Program, which is similar to ERDA's NURE program but smaller in scope. During 1976, the program covered approximately 214,000 square miles including 174,000 by airborne gamma spectrometry and 85,000 by regional geochemistry.

In late December, the Dominion Government announced that exports of uranium and Canadian nuclear reactors will be allowed only to countries that ratify the Non-Proliferation Treaty or otherwise accept international safeguards for their nuclear programs. The new policy became effective on January 1, 1977.

Canada's national uranium policy, enacted late in 1974, requires at least a 30-year reserve for nuclear fuel for existing, committed, and planned reactors in any 10-year forward period. Allocations amounting to 21% of each producer's reserves have been applied to provide for the 30-year fueling requirements of about 90,000 tons of U_3O_8 for the 16,240 megawatts of nuclear capacity expected to be operating in Canada by 1987. As of June 1976, uranium producers had export commitments of about 110,000 tons of U_3O_8 and domestic commitments of 33,000 tons of U_3O_8. Production was expected to increase significantly in the next 10 years to meet contract commitments and anticipated demand for uranium. Uranium output was expected to reach 10,300 tons of U_3O_8 in 1980 and 16,200 tons in 1984.[25]

Government estimates of Canada's recoverable uranium resources in short tons follow:

Minable	Measured	Indicated	Inferred
Up to $40 per pound of U_3O_8	103,000	115,000	309,000
Up to $60 per pound of U_3O_8	5,000	14,000	90,000
Total	108,000	129,000	399,000

Uranium production in 1976 came from five operations—Denison Mines Ltd., Rio Algom Ltd., and Madawaska Mines Ltd., in Ontario, and Eldorado Nuclear Ltd. (ENL) and Gulf Minerals Canada Ltd./Uranerz Canada Ltd. in northern Saskatchewan. Shipments from these operations totaled 6,678 tons of U_3O_8, an increase of 595 tons over those of 1975.

Denison Mines Ltd. reported increased uranium output for the third successive year, reaching 1,556 tons of U_3O_8, about 7% higher than in 1975. Mill throughput was up 13.6% to about 1.7 million tons, but ore grade decreased from 2.30 pounds of U_3O_8 per ton to 2.16 pounds. The mill expansion to 7,100 tons of ore per day was completed

[23] American Metal Market. Brazilian Geologists Discover Extensive Uranium Reserves. V. 83, No. 146, July 20, 1976, p. 8.

[24] Williams, R. M. Uranium. Can. Min. J., v. 98, No. 2, February 1977, pp. 145-160.

[25] Canadian Department of Energy, Mines and Resources. 1976 Assessment of Canada's Uranium Supply and Demand. Report EP 77-3, June 1977, 19 pp.

in early 1976, and the company was increasing ore output to run the mill at capacity. Ore-handling capacity was to be increased, and the No. 1 shaft was being rehabilitated for use as a production shaft.

In October, Rio Algom announced plans to reactivate the Panel mine and mill which are east of the company's Quirke mine.[26] The project, expected to cost about $100 million, was to be completed in 1980. Initial mill capacity was planned at 3,000 tons per day. Rio Algom was also well along with its $76 million expansion of the Quirke complex. The expansion of mill capacity from 4,500 tons per day to 7,000 tons per day was expected to be completed in 1978.

ENL continued a 5-year, $44 million program to increase uranium production at the Beaverlodge mine and mill in Saskatchewan. Plans called for increasing output to 1.5 million pounds of U_3O_8 by yearend 1977 and to 2 million pounds of U_3O_8 by 1979. Production in 1976 was 1,187,846 pounds of U_3O_8.

The Gulf/Uranerz uranium operation, which began production at Rabbit Lake, Saskatchewan, in late 1975, reached full capacity in the third quarter of 1976. The company, which has a mill designed to process 1,800 tons of ore per day, anticipated an annual production of about 2,200 tons of U_3O_8.

Madawaska Mines Ltd., a joint venture of Federal Resources Ltd. (51%) and Consolidated Canadian Faraday Ltd. (49%), reopened the Faraday mine and mill and began ore production at a daily rate of 750 tons in August.[27] Full capacity, 1,500 tons of ore daily, was expected in early 1977. Amok Ltd., owned entirely by French interests (Compagnie de Mokta, Cie. Française des Minerais d'Uranium, Péchiney Ugine Kuhlmann, and Commissariat à l'Energie Atomique), planned to bring its Cluff Lake deposit in northern Saskatchewan into production in 1977. A two-phase operation was envisioned, at a total cost of $133 million. The first phase involved the mining and milling of high-grade ore from the D-ore body at a rate of about 80 tons per day in 1979, followed by a second-phase mill with a milling rate of 1,200 to 1,500 tons per day in 1981 or 1982 for an annual output of 1,700 tons of U_3O_8. Amok's development program could be significantly delayed, however, owing to a yearend announcement by the Saskatchewan Government that it planned to hold hearings relative to the Cluff Lake operation. Agnew Lake Mines Ltd. (ALM) completed a $3 million program, begun in 1974, to test large-scale leaching of uranium from broken ore both on surface and underground. In March, ALM announced a $37 million project designed to produce 1 million pounds of U_3O_8 per year.[28] The mine, near Espanola, Ontario, was dewatered, and underground development was in progress.

France.— COGEMA, a new group formed by the Commissariat à l'Energie Atomique, was the major uranium producer with a mine output from three operations of 2,258 tons of U_3O_8 in 1976, or almost 84% of total production. Production from France's eight active uranium mines, in tons in 1976 follows:

Mine	Ore production	U_3O_8 content
Limousin	377,000	963
Vendée	384,000	697
Forez	139,000	598
Lozere	151,000	211
Creuse	16,000	65
Morbihan	8,000	47
Corrèze	8,000	35
Cantal/Creuse	36,000	84
Total	1,119,000	2,700

Uranium concentrate output was 3,144 tons of U_3O_8, of which 788 tons was derived from preconcentrated material imported from Gabon.[29]

Italy.—AGIP Mineraria planned to develop uranium deposits near Novazza in Bergamo Province. Mining operations were expected to begin in 1979 and to continue for about 10 years.[30] Mineralization occurs in small separate deposits, the largest of which contains about 1,650 tons of U_3O_8.

Mexico.—The Institute Nacional de Energia Nuclear (INEN) increased its efforts to provide the uranium necessary to sustain Mexico's nuclear power program, projected to be 15,000 megawatts electric by 1990. The program was estimated to require 250 million pounds of U_3O_8. Exploration activity was centered in the States of Chihuahua and Tamaulipas, where significant deposits have been found. The major deposits were Las Margaritas, with reserves of 9 million

[26]American Metal Market. Rio Algom To Reactivate Ontario Panel Mine, Mill. V. 82, No. 218, Nov. 9, 1976, p. 11.

[27]Canadian Mining Journal. 1,500 Tpd Faraday Mine Reopened. V. 97, No. 10, October 1976, p. 67.

[28]Northern Miner. Kerr Addison Plans Agnes Start Within Two Years. V. 61, No. 52, Mar. 11, 1976, pp. 1, 16.

[29]Annales des Mines. V. 183, No. 9-10, September-October 1977, pp. 33-34.

[30]Mining Magazine. Italian Uranium. V. 135, No. 5, November 1976, p. 475.

pounds of U_3O_8 and Nopal with reserves of 2 million pounds of U_3O_8, in Chihuahua State, and LaComa and Buenavista with reserves of about 6 million pounds of U_3O_8 in Tamaulipas State.

Niger.—The Arlit mine of Sociètè des Mines de L'Air (SOMAIR), an international consortium composed of Niger, French, Italian, and West German interests, was the only uranium producer in 1976. Production was 1,898 tons of U_3O_8 in 1976, compared with 1,820 tons in 1975. Another international consortium (Niger, French, Japanese, and Spanish), the Compagnie Miniere d'Akouta, was developing the Akouta uranium mine 5 miles south of the Arlit mine. The Akouta mining complex, which will cost $200 million, was expected to begin production in 1978 and reach an output level of 2,200 tons of U_3O_8 annually by 1980.

At Imouraren, a joint venture composed of Niger's Uraniger (30%), Continental Oil Co. (35%), and the French Commissariat à l'Energie Atomique (35%) expected to complete the drilling of 500 exploratory holes by mid-1977. Results have been favorable, and production might be possible by 1981.

Major exploration for uranium was carried out by several foreign companies in 1976. Most efforts were centered in 10 concession areas largely in the north-central and northeast parts of Niger.

South Africa, Republic of.—In 1976, uranium output, as a byproduct and coproduct from eight gold mines and one copper mine, totaled 3,587 tons of U_3O_8, an increase of 353 tons over that of 1975. The uranium content in gold ore processed continued to decline, decreasing from 0.454 pound of U_3O_8 per metric ton in 1974 to 0.417 pound in 1975 and to 0.397 pound in 1976. Production by gold mines in 1976 follows:

Mine	Pounds of U_3O_8
Blyvooruitzicht	288,996
Buffelsfontein	1,337,994
Harmony	1,096,344
Hartebeestfontein	768,734
Vaal Reefs	2,233,658
West Driefontein	500,945
Western Deep Levels	308,702
West Rand Consolidated	325,189
Total	6,860,562

Palabora Mining Co. reported a 1976 production of 315,926 pounds of U_3O_8 in calcine, an increase of about 40,000 pounds over 1975.

Government estimates indicated that expected uranium oxide output for South Africa and South-West Africa would be about 10,000 tons by 1978. The Anglo American Corp. of South Africa Ltd. opened its large-scale coproduct complex at its President Brand mine in the Orange Free State in August. The complex and beneficiation plants are designed to process tailings slime from seven area mines—President Brand, President Steyn, Free State Geduld, Welkom, Western Holdings, Free State Saayplaas, and Freddies. Principal products expected to be produced were pyrite for sulfuric acid production, gold, and uranium. When fully operational, annual uranium oxide output was projected to be about 1.3 million pounds.

East Rand Gold and Uranium Co. Ltd. planned to extract uranium, gold, and pyrite from 19 slimes dams containing about 415 million tons of slime at an overall grade of 0.015 troy ounce of gold, 1.16 pounds of uranium, and about 21 pounds of sulfur per ton of slime. Commissioning of the various plants was planned for late 1977 with production starting in early 1978. Annual production, after a few months' buildup period, was expected to be 7.7 tons of gold, 220 tons of uranium, and 580,000 tons of sulfuric acid.

Vaal Reefs Exploration and Mining Co., Ltd., and Randfontein Gold Mines, Ltd., were both expanding their uranium plants. West Rand Consolidated, Ltd., a nonproducer of uranium in 1975, owing to modernization and expansion of its uranium plant, resumed uranium production in 1976. The upgraded plant has an annual capacity of about 1 million pounds of U_3O_8.

South-West Africa, Territory of.—In October, Rossing Uranium Ltd. announced that full production would be delayed 18 months to 1978 owing to the need for ore-processing equipment replacement and mechanical changes to rectify construction faults. Estimated uranium output in 1976 was 770 tons of U_3O_8. Production was expected to reach half the ultimate production level, 5,000 tons U_3O_8 annually, by mid-1977.

General Mining and Finance Corp. Ltd. reported the finding of a large calcrete-type uranium deposit at Langchenrich in the Swakopmund district. Metallurgical problems were delaying development of the deposits.

Sweden.—Luossavaara-Kiirunavaara Aktiebolag planned to develop a small uranium mine at Pleutajokk in Lappland to supplement production from the Ranstad mine in southern Sweden. Plans called for the mining of 200 tons of ore per day beginning in 1980. The Pleutajokk deposit was estimated to have 2,200 tons of U_3O_8 reserves. Planned expansion of the Ranstad mine was postponed because of environmental problems.

TECHNOLOGY

ERDA continued to enlarge its NURE program, stepping up both airborne radiometric and geochemical surveys and developing new technologies to improve uranium exploration mining and extraction.[31] Many reports and maps resulting from the program were published in 1976.[32] In June, ERDA issued the preliminary NURE report.[33]

The U.S. Geological Survey and ERDA continued development of automated delayed neutron activation analysis and design, and tested a downhole californium-252 neutron-generating probe capable of detecting uranium concentrations as low as 0.01%. In the United Kingdom, a towed seabed spectrometer, used for continuous seabed surveys, was developed.[34] The device has operated at depths up to 1,000 feet. The alphameter, an instrument that measures alpha particles emitted by radon, reportedly was easier to use, cheaper, and more reliable than older uranium emanometer prospecting methods.[35]

A rapid procedure for measuring uranium in natural waters using thermal neutron activation and anion-exchange separation of uranium was reported to have a detection limit of 0.05 part per billion.[36] A comparison of analytical methods to determine uranium in granitic rocks was made.[37] A combination of delayed-neutron determinations for uranium and gamma ray spectrometric analyses of radium equivalent uranium, thorium, and potassium provided the best data base for geochemical prospecting.

Increasing demand and high uranium prices continued to stimulate Government and industry interest in solution mining as a means to reduce investment and construction lead times, to produce from low-grade ore bodies, and to minimize environmental problems. A generalized cost model for current solution mining practices was developed.[38] Operating costs accounted for 60% of total costs and capital costs for about 40%. Estimated costs per pound of production ranged from $13.94 for a 1-million-pound-of-U_3O_8-per-year operation to $17.19 for a 250,000-pound operation.

The Bureau of Mines expanded its research and development work on processing technology for recovering uranium from low-grade and refractory ores. Beneficiation and leaching of granites from Wyoming and Vermont were studied. Also investigated in 1976 were ores resistant to acid leaching; these ores proved to be readily leachable after they were subjected to autoclave oxidation or to roasting.

The South African National Institute for Metallurgy was developing and pilot-plant-testing a lower cost continuous-ion-exchange (CIX) process for uranium extraction.[39] Capital costs of a uranium plant using the CIX process were estimated to be 20% lower than costs of one using the Purlex process. Resin use was also cutto one-third to one-half that of fixed-bed ion exchange, and unlike Purlex, CIX operated satisfactorily in solutions containing suspended solids. The process reportedly was particularly well suited to in situ and heap leaching solutions.

Another process similar to the CIX process was undergoing pilot plant tests to extract uranium at Elliott Lake, Canada. The first full-scale installation was to commence operation at a new Canadian uranium mill in 1977.[40]

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[31] Energy Research and Development Administration. Uranium Geophysical Technical Symposium, Summaries and Visual Presentations. Grand Junction, Colo., Sept. 14-16, 1976, 260 pp.

[32] Energy Research and Development Administration. Grand Junction (Colo.) Office. ERDA Lists Reports Issued in 1976. News Release 77-4, Jan. 14, 1977, 9 pp.

[33] Energy Reaearch and Development Administration. National Uranium Resource Evaluation, Preliminary Report. GJO-111(76), (Grand Junction, Colo.), June 1976, 132 pp.

[34] Mining Journal. New Instruments for Uranium Exploration. V. 286, No. 7344, May 21, 1976, p. 409.

[35] Canadian Mining Journal. Alphameters: Uranium Prospecting by Radon Detection. V. 97, No. 4, April 1976, pp. 28-34.

[36] Analytical Chemistry. Determination of Uranium in Natural Waters by Neutron Activation Analysis. V. 48, No. 7, July 1976, pp. 973-975.

[37] Struckless, J. S., et al. A Comparison of Some Analytical Techniques for Determining Uranium, Thorium, and Potassium in Granitic Rocks. U.S. Geol. Survey J. Res., v. 5, No. 1, January-February 1977, pp. 83-91.

[38] Frank, J. N. Cost Model for Solution Mining of Uranium. Pres. at the Uranium Industry Seminar, Grand Junction, Colo., Oct. 19-20, 1976, 25 pp. Available from Grand Junction, (Colo.) Office, Energy Research and Development Administration.

[39] James, H. E. Recent Trends in Research and Development Work on the Processing of Uranium Ore in South Africa. Republic of South Africa Atomic Energy Board, PEL-253, July 1976, 14 pp.

[40] Mining Journal (London). Ion Exchange Technique Used for Uranium Extraction in Canada. V. 287, No. 7354, July 30, 1976, p. 82.

Research continued on novel uranium-enrichment methods.[41] A variation of the West German nozzle process using a higher percentage of carrier gas was believed to accelerate the lighter uranium isotopes. The technique is called "seeded beam separation." Asahi Chemical Industry Co., Ltd., in Japan reported that it had successfully developed a technique combining chromatography and ion-exchange resin for enriching uranium.[42] Power consumption was estimated at half that required by gas centrifuge methods. TRW, Inc. was developing a method of uranium isotope separation by a plasma-electromagnetic effect, known as the Dawson separation process.[43] In the Dawson process, natural uranium is introduced into a plasma and subjected to magnetic and radio frequency fields. The U-235 nuclei resonate to different fields than other uranium isotopes and then can be isolated.

NRC continued efforts to improve LWR safety. Research was directed toward developing methods of calculating the course of events if an accident should begin. To assist this effort, NRC conducted tests at the Power Burst Facility (PBF) at the Idaho National Engineering Laboratory to provide data to define the behavior of nuclear fuels under abnormal and hypothetical accident conditions. The Loss-of-Fluid-Test program (LOFT), NRC's largest experimental facility, was completed, and the first experiments were conducted in 1976. The LOFT facility was designed to provide verification of analytical methods used for prediction of integrated system behavior in a loss-of-coolant accident.

ERDA continued its basic research and development program on four breeder concepts—the liquid metal fast breeder reactor (LMFBR), the light water breeder, the gas-cooled breeder, and the molten-salt breeder. Reference designs, work schedules, and cost data were established for the demonstration Clinch River LMFBR in Tennessee. ERDA planned to have the facility completed in 1983; however, late in the year the President indicated that he would recommend delaying the development of the breeder reactor. The Flux Test Facility for testing breeder fuels and materials, and for safety and reactor development experience, was expected to be completed in 1977. Progress was made in studies on advanced oxide fuels and higher breeding mixed uranium-plutonium carbide and nitride fuels.

Development of the Actinide Nitride-Fueled (ANF) reactor was proposed as a possible means to recycle nuclear waste, sharply reduce problems of environmental safety and radioactive waste storage, and minimize the risks of theft or attack by terrorists.[44] The recycling aspects of the system reportedly would permit almost 90% cost savings over presently accepted methods.

Research directed toward preventing theft of weapons-grade uranium and plutonium increased substantially in 1976. Plant security improved, and proposals for international fuel fabrication and reprocessing centers were advanced. ERDA proposed co-processing of uranium and plutonium in mixed oxide fuels in order to prevent plutonium from existing as a separate entity anywhere in the fuel cycle. Battelle Columbus Laboratories was studying the addition of long-lived actinides to fuel elements, which would make the fuel elements so radioactive that remote control equipment is required, thereby making theft difficult. Similarly, irradiation of fuel elements to make them too radioactive to handle was proposed.

Conversion to a thorium fuel cycle was advanced as a means to help prevent worldwide proliferation since very little plutonium is created in the cycle and the bred U-233 can only be separated from the other uranium isotopes present by enrichment techniques.[45]

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[41]Chemical Engineering. Uranium-Enrichment Update. V. 84, No. 2, Jan. 17, 1977, pp. 77-80.

[42]Chemical Week. Asahi Chemical's Nuclear Enrichment Technique Cuts Power Needs. V. 118, No. 13, Mar. 31, 1976, p. 31.

[43]Nuclear News. ERDA Funds TRW's Look at New Separation Process. V. 19, No. 13, October 1976, p. 40.

[44]Industrial Research. Meet the ANF Reactor. No. 104, May 1976, pp. 55-58.

[45]Von Hippel, F., and R. H. Williams. Energy Waste and Nuclear Power Growth. Bull. of the Atomic Scientists, v. 32, No. 10, December 1976, pp. 18-21, 48.

Vanadium

By Grace N. Broderick[1]

Consumption of vanadium in 1976 in the United States was 14% less than in 1975, and 34% less than the alltime high of 7,200 short tons of contained vanadium reported in 1974. Domestic production of vanadium oxide, however, was considerably higher than in 1975. Arkansas, for the fifth consecutive year, was the leading vanadium-producing State. Both exports and imports of ferrovanadium increased in 1976. Exports classified as ores, concentrates, oxides, and vanadates were at a much lower level than in 1975. Vanadium pentoxide imports, which until 1974 were insignificant, accounted for about 16% of total vanadium imports for consumption in 1976. U.S. price quotations for the principal vanadium materials, which remained stable in 1975, increased about 10% in mid-1976.

Requests for high-purity vanadium metal continued to be received by the Bureau of Mines; a total of 16 pounds was supplied to the Oak Ridge National Laboratory and to the University of Illinois for research purposes.

Table 1.—Salient vanadium statistics

(Short tons of contained vanadium)

	1972	1973	1974	1975	1976
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium[1]	4,887	4,377	4,870	4,743	7,376
Value (thousand dollars)	$30,867	$26,611	$38,266	$49,329	$81,279
Vanadium oxides recovered[2]	5,248	4,864	5,368	4,859	6,197
Consumption	5,227	6,393	7,200	5,501	4,720
Exports:					
Ferrovanadium and other vanadium alloying materials (gross weight)	269	1,416	1,335	1,018	1,210
Vanadium ores, concentrates, oxides, and vanadates	176	232	203	215	99
Imports (general):					
Ferrovanadium (gross weight)	578	303	225	179	433
Ores, slags, residues	1,400	2,600	2,485	2,895	2,998
Vanadium pentoxide (anhydride)	(3)	(3)	533	1,275	668
World production	20,239	21,653	r20,762	r23,201	25,950

rRevised.

[1]Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

[2]Produced directly from all domestic sources and includes metavanadates.

[3]Less than 1/2 unit.

Legislation and Government Programs.—As of December 31, 1976, the physical inventory of the U.S. Government stockpile remained at 540 tons of vanadium, all in the form of vanadium pentoxide. New stockpile goals for strategic and critical minerals were announced by the General Services Administration on October 1; those for vanadium were 10,095 tons of ferrovanadium and 2,576 tons of vanadium pentoxide.

[1]Physical scientist, Division of Ferrous Metals.

DOMESTIC PRODUCTION

Four mills produced vanadium pentoxide from domestic sources in the United States during the year. Union Carbide Corp. continued to operate both its Uravan-Rifle mill complex in Colorado, and its Hot Springs, Ark., mill; Kerr-McGee Corp. operated its Soda Springs, Idaho, plant; and Atlas Corp., Moab, Utah, began recovering vanadium early in 1976. Colorado Plateau uranium-vanadium ores, Arkansas vanadium ore, and Idaho ferrophosphorus constituted the domestic raw materials that were run through the mills. Other sources included vanadium-bearing slags from Chile, •the U.S.S.R., and the Republic of South Africa and spent catalysts and powerplant residues from U.S. and Caribbean sources. Vanadium recovered from imported vanadium-bearing materials was not included in any of the production figures shown in the tables, nor was the vanadium recovered directly from slags or residues as ferrovanadium or similar products.

The Cotter Corp., a wholly-owned subsidiary of Commonwealth Edison Co., Inc. of Chicago, awarded a contract for the design and construction of a $26.1 million uranium-vanadium processing facility at Canon City, Colo. In addition to a new ($23.5 million) mill that will process 1,000 tons of ore per day, the facility will include a plant ($2.6 million) for recovery of vanadium, molybdenum, nickel, cobalt, and tungsten from spent catalysts. Startup of the mill is not expected until 1978 or early 1979.

Ranchers Exploration and Development Corp. planned to rework, for its residual uranium-vanadium content, tailing remnants of uranium-vanadium milling operations conducted in 1943-63 at Naturita and Durango, Colo., by Vanadium Corp. of America. The tailings totaled around 2 million tons; about 600,000 tons of this is located at Naturita, and 1.5 million tons is at Durango. The tailings will be removed from their present sites to locations where they can be leached and processed by solvent extraction. It has been reported that about 1,100 pounds of U_3O_8 and 4,000 pounds of V_2O_5 per day are expected to be produced. Production from the Naturita tailings pile is to begin in late November 1977 and continue for approximately 16 months; production from the Durango tailings is projected to begin in mid-1979 and to continue for about 32 months.

Long Island Lighting Co. (LILCO) reported that sales of vanadium produced as a byproduct of the burning of Venezuelan oil in its power-generating operations over the past 12 years have produced more than $5 million in revenues.

Table 2.—Mine Production and recoverable vanadium of domestic origin produced in the United States

(Short tons of contained vanadium)

Year	Mine production[1]	Recoverable vanadium[2]
1972	4,699	4,887
1973	4,117	4,377
1974	5,240	4,870
1975	5,213	4,743
1976	8,076	7,376

[1]Measured by receipts of uranium and vanadium ores and concentrates at mills, vanadium content.
[2]Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

Table 3.—Production of vanadium oxides in the United States[1]

(Short tons)

Year	Gross weight	Oxide content[2]
1972	10,410	9,367
1973	8,226	8,683
1974	9,304	9,583
1975	8,597	8,674
1976	10,836	11,063

[1]Produced directly from all domestic sources; includes metavanadates.
[2]Expressed as equivalent V_2O_5.

CONSUMPTION AND USES

Domestic consumption of vanadium, reported by type of material in table 4 and by end-use category in table 5, decreased 14% in 1976 from that of 1975 and 34% from the alltime record high of 7,200 tons established in 1974. Decreases occurred in nearly all end-use categories, tool steel being the one noteworthy exception as it increased 37% over that of 1975. Stainless and heat-resisting steel and full-alloy steel remained at about the same level of consumption as in 1975. Reduced activity in aircraft construction and less demand for carbon steel and high-strength low-alloy steel contributed significantly to the drop in consumption.

Eighty-eight percent of the vanadium was consumed as ferrovanadium and associated proprietary vanadium-iron-carbon materials. Compared with data for 1975, ferrovanadium (including proprietary materials) consumption fell 12% and oxide consumption declined 19%. Consumption of ammonium metavanadate, however, increased 58%. Consumption of other vanadium materials, consisting principally of vanadium-aluminum alloys and small quantities of other vanadium alloys, was 35% below that of 1975.

Table 4.—Consumption and consumer stocks of vanadium materials in the United States

(Short tons of contained vanadium)

Type of material	1975		1976	
	Consumption	Ending stocks	Consumption	Ending stocks
Ferrovanadium[1]	4,703	868	4,144	924
Oxide	216	56	175	50
Ammonium metavanadate	26	5	41	9
Other[2]	556	212	360	97
Total	5,501	1,141	4,720	1,080

[1]Includes other vanadium-iron-carbon alloys.
[2]Consists principally of vanadium-aluminum alloy, plus relatively small quantities of other vanadium alloys and vanadium metal.

Table 5.—Consumption of vanadium in the United States, by end use

(Short tons of contained vanadium)

End use	1976
Steel:	
Carbon	516
Stainless and heat resisting	21
Full alloy	1,311
High-strength low-alloy	1,636
Electric	W
Tool	565
Cast irons	61
Superalloys	19
Alloys (excluding steels and superalloys):	
Cutting and wear resistant materials	W
Welding and alloy hard-facing rods and materials	9
Nonferrous alloys	313
Other alloys[1]	W
Chemical and ceramic uses:	
Catalysts	212
Other[2]	W
Miscellaneous and unspecified	57
Total	4,720

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."
[1]Includes magnetic alloys.
[2]Includes pigments.

STOCKS

In addition to the consumers' stocks shown in table 4, producers' stocks of vanadium as fused oxide, precipitated oxide, metavanadate, metal, alloys, and chemicals totaled 3,018 tons of contained vanadium at yearend 1976, compared with 3,375 tons at yearend 1975.

PRICES

Prices in the United States for the principal vanadium materials increased about 10% at midyear. The price for domestic 98% fused vanadium pentoxide, as quoted by Metals Week, began the year as a dual quotation of $2.45 and $3.06 per pound of contained V_2O_5 and increased to $2.75 and $3.35. Prices for technical-grade air-dried vanadium pentoxide per pound of contained V_2O_5 were raised from $2.45 to $2.75 on August 1, 1976, by Kerr-McGee Corp. and from $3.06 to $3.35 on July 1, 1976, by Union Carbide Corp.; Foote Mineral Co.'s air-dried vanadium pentoxide price has been posted at $3.54 per pound of contained V_2O_5 since January 10, 1975.

Metals Week, as of midyear, no longer published a price quotation for U.S. standard grade (70% to 75% vanadium) ferrovanadium, which had been quoted at $6.35 per pound of contained vanadium since November 1974. It began publishing, effective July 1, a new price quotation of $6.10 per pound of contained vanadium for U.S. producer 80% vanadium grade ferrovanadium. The price per pound of contained vanadium for both Carvan and Ferovan, effective July 1, rose from $5.10 to $5.60.

Metal Bulletin's United Kingdom price for ferrovanadium containing 50% to 60% vanadium was quoted as £5.30 to £5.40 at the beginning of the year and ended the year at £7.30 to £7.60.

FOREIGN TRADE

Exports of ferrovanadium were up about 19% in 1976. Exports of ores, concentrates, and oxides, however, were at a much lower level than in 1975, declining by 54%. Average declared value for exports of ores, concentrates, and technical-grade oxides remained about the same, $2.11 per pound of contained vanadium pentoxide in 1976, compared with $2.12 per pound in 1975. The average declared value for exports of ferrovanadium was $3.79 per pound of alloy in 1976, compared with $3.91 in 1975.

No imports classified as vanadium ore and concentrate were received in 1976. Imports classified as vanadium carbide totaled 525 pounds (gross weight), all of which came from West Germany. Imports of vanadium-bearing materials (such as ashes and slags) totaled 6.0 million pounds of contained vanadium, compared with 5.8 million pounds of contained vanadium in 1975. In both years, the Republic of South Africa, the U.S.S.R., and Chile were the major sources of this supply. Vanadium pentoxide (anhydride) imports decreased significantly from those of 1975, with imports for consumption in 1976 totaling 2,184,241 pounds (gross weight) valued at $3,481,047, compared with 4,297,303 pounds (gross weight) valued at $7,873,796 in 1975. Ferrovanadium imports in 1976, shown in table 7, came largely from West Germany and Norway; in terms of the vanadium content, they were about double the 1975 ferrovanadium imports.

Table 6.—U.S. exports of vanadium, by country

(Thousand pounds and thousand dollars)

Destination	Ferrovanadium and other vanadium alloying materials containing over 6% vanadium (gross weight)				Vanadium ore, concentrates, pentoxide, vanadic acid, vanadium oxide, and vanadates (except chemically pure grade) (vanadium content)			
	1975		1976		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	17	70	40	172	--	--	--	--
Austria	--	--	--	--	174	788	--	--
Belgium-Luxembourg	111	405	110	394	--	--	--	--
Canada	745	3,055	780	3,236	6	27	65	206
China, People's Republic of	--	--	--	--	5	15	--	--
Finland	--	--	33	122	--	--	--	--
France	4	18	--	--	--	--	--	--
Germany, West	6	12	41	128	139	361	--	--
India	135	452	1	3	--	--	23	100
Italy	--	--	--	--	--	--	5	20
Japan	160	587	718	2,414	55	207	--	--
Malaysia	1	2	1	4	--	--	--	--
Mexico	--	--	16	57	52	230	50	233
Netherlands	388	1,618	132	527	--	--	--	--
New Guinea	--	--	--	--	--	--	(1)	1
Peru	--	--	--	--	--	--	1	1
Poland	--	--	107	399	--	--	--	--
Spain	43	171	230	934	--	--	53	181
Sweden	304	1,022	121	504	--	--	--	--
Switzerland	63	284	70	204	--	--	--	--
Venezuela	59	256	--	--	--	--	--	--
Yugoslavia	--	--	22	82	--	--	--	--
Total	2,036	7,952	2,422	9,180	431	1,628	197	742

[1]Less than 1/2 unit.

Table 7.—U.S. imports of ferrovanadium, by country

(Thousand pounds and thousand dollars)

Country	1975			1976		
	Gross weight	Vanadium content	Value	Gross weight	Vanadium content	Value
General imports:						
Austria	77	53	294	55	45	219
Brazil	44	31	155	--	--	--
Canada	16	12	68	91	69	371
Germany, West	222	177	918	323	238	1,200
Norway	--	--	--	353	166	656
Sweden	--	--	--	44	36	172
Total	359	273	1,435	866	[1]553	2,618
Imports for consumption:						
Austria	77	53	294	55	45	219
Brazil	44	31	155	--	--	--
Canada	16	12	68	91	69	371
Germany, West	222	177	918	279	202	1,029
Norway	--	--	--	353	166	656
Sweden	--	--	--	44	36	173
Total	359	273	1,435	822	518	2,448

[1]Data do not add to total shown because of independent rounding.

Table 8.—U.S. imports of vanadium pentoxide (anhydride), by country

Country	1975			1976		
	Gross weight (pounds)	Vanadium content (pounds)	Value	Gross weight (pounds)	Vanadium content (pounds)	Value
General imports:						
Canada	1,682	942	$303	--	--	--
Finland	44,974	25,194	124,209	--	--	--
Germany, West	99,498	55,739	241,319	--	--	--
South Africa, Republic of	4,404,727	2,467,528	7,940,330	2,383,754	1,335,379	$3,766,686
United Kingdom	1	(1)	255	665	373	2,851
Total	4,550,882	[2]2,549,404	8,306,416	2,384,419	1,335,752	3,769,537
Imports for consumption:						
Canada	1,682	942	303	--	--	--
Finland	44,974	25,194	124,209	--	--	--
Germany, West	99,498	55,739	241,319	--	--	--
South Africa, Republic of	4,151,148	2,325,473	7,507,710	2,183,576	1,223,239	3,478,196
United Kingdom	1	(1)	255	665	373	2,851
Total	4,297,303	[2]2,407,349	7,873,796	2,184,241	1,223,612	3,481,047

[1]Less than 1/2 unit.
[2]Data do not add to total shown because of independent rounding.

WORLD REVIEW

In addition to the nations listed in table 9, some others had relatively small vanadium production from secondary, waste, or byproduct sources. Japan and West Germany produced vanadium from several such sources. Pipeline production continued to be a major factor in world demand.

Australia.—Western Mining Corp. Ltd.'s prospective uranium mine at Yeelirrie, Western Australia, may also produce byproduct vanadium pentoxide. Annual output would start around 1982 and would be about 1,000 tons of V_2O_5 per year.

Bolivia.—Construction of a ferroalloys plant in Bolivia, which was to have begun in January 1977, was postponed by Empresa Nacional de Fundaciones (ENAF). Marketing and financial considerations were given as factors in delaying the project for 1 year. In addition to producing 500 tons annually of ferrotungsten from Bolivia's tungsten concentrates, the planned facility would have capacity to produce ferrovanadium. The latter production would be from imported concentrates because Bolivia does not produce vanadium.

Table 9.—Vanadium: World production from ores and concentrates, by country

(Short tons of contained vanadium)

Country	1974	1975	1976[p]
Chile[e1]	640	660	1,199
Finland (in vanadium pentoxide product)	1,635	1,405	1,598
Norway[e]	[r]500	[r]510	580
South Africa, Republic of: [2]			
Content of pentoxide and vanadate product[e]	3,657	5,300	3,931
Content of vanadiferous slag product[e]	5,327	6,434	6,954
Total	8,984	11,734	10,885
South West Africa, Territory of (in lead vanadate concentrate)[3]	903	619	782
U.S.S.R. (in slag exports only)[e]	3,230	3,530	3,530
United States (recoverable vanadium)	4,870	4,743	7,376
Total	[r]20,762	[r]23,201	25,950

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Based on U.S. imports.
[2]The Republic of South Africa officially reports the undistributed total production of vanadium in pentoxides and vanadate products as well as in vanadium bearing slags. Data on vanadium content of vanadium slag are estimated on the basis of a reported tonnage of vanadium bearing slag (gross weight) multiplied by an assumed grade of 14% vanadium. Vanadium content of pentoxide and vanadate products represents the difference between the reported total and the calculated estimate for vanadium in slag.
[3]Data represent output of South West Africa Co. Ltd. for the years ending June 30 of that stated.

Finland.—According to Finnish trade statistics, Finland exported 2,653 tons of vanadium compounds[2] in 1975, compared with 2,955 tons in 1974. Of the 2,653 tons, 672 tons went to France, 590 tons to Sweden, 450 tons to West Germany, 364 tons to Great Britain, 331 tons to the U.S.S.R., 165 tons to Czechoslovakia, 46 tons to Brazil, 23 tons to the United States, 12 tons to Mexico, and negligible amounts to Spain and Italy.

Rautaruukki Oy reported an output of 2,854 tons (gross weight) of vanadium pentoxide in 1976, of which 2,424 tons came from the Otanmäki mine and 430 tons from the Mustavaara mine. Production at the Mustavaara mine began in May 1976; because most of the year was consumed by trial runs of the various processes and repairing faults discovered, only minor quantities of vanadium pentoxide could be obtained from this mine.

Germany, West.—According to official trade statistics, West Germany imported 22,602 tons (gross weight) of vanadium-containing ashes, residues, and slag in 1976, compared with 29,674 tons (gross weight) in 1975.

India.—Ferrovanadium production was 58 tons in 1976, compared with 55 tons in 1975 and 72 tons in 1974.

Yearly production of vanadium sludge was reported to be around 1,760 tons from two alumina plants— the Bharat Aluminium Co.'s (BALCO) plant at Korba in Madhya Pradesh, with a capacity of about 880 tons of sludge per year; and Hindustan Aluminium Corp. Ltd's (HINDALCO) plant at Renukoot in Uttar Pradesh, also with an annual capacity of about 880 tons. HINDALCO was in the process of increasing its capacity to 1,320 tons of sludge per year. Indian Aluminium Co. Ltd. (INDALCO) was examining the feasibility of vanadium recovery from sludge in a pilot project at its Muri (Bihar) alumina plant, and eventually expects to recover about 330 tons of sludge per year from each of its two alumina plants at Muri (Bihar) and Belgaum (Karnataka).

Philippines.—Filmag (Philippines) Inc., the second largest iron sand processor in the Philippines, was reportedly constructing, in cooperation with Japan's Mitsubishi Corp., a 4,400-ton-per-year ferrovanadium plant at Luzon. They also have planned to build in 1978 a 6,000-ton-per-month pig iron plant (using Lingayen iron sand), which also would produce a 15% vanadium slag.

Sweden.—MX-Processor AB, Mölndal, Sweden, has developed a new process for recovering vanadium from flue dust produced at heavy-oil-fired power stations. Plans call for building a large pilot plant adjacent to the Stenungsund power station. The plant would be capable of recovering about 100 tons per year of vanadium worth about $660,000 with startup expected in 1978.

South Africa, Republic of.—South Africa continued to be the world's leading vanadium-producing country. Vanadium statistics published by the South African Government's Department of Mines were for the combined forms— slag, polyvanadate and metavanadate, and fused pentoxide as V_2O_5. In this combined form, production in 1976 totaled 19,431 tons, compared with 20,946 tons in 1975.

Production of vanadium-bearing slag by Highveld Steel and Vanadium Corp. Ltd.—South Africa's and the world's leading producer of vanadium—totaled 49,671 tons (gross weight) in the fiscal year ending June 30, 1976, compared with 45,955 tons (gross weight) in the previous fiscal year. Highveld's ore originates from the Steelpoort Roosenekal area of the Transvaal. It is smelted at Witbank, where a sixth kiln was commissioned in October and major overhauls and uprating were carried out on the original four. The company's Vantra Division, which produces fused vanadium pentoxide, took its small kilns out of operation in December 1975 for major repairs and modifications and recommissioned them in April 1976.

TECHNOLOGY

Aspects of the geology of vanadium as a framework for appraising resources of this commodity in the light of present-day technology, economics, and geologic knowledge were discussed in a report by the U.S. Geological Survey. Geologic habits of base-metal vanadates and of titaniferous magnetite deposits were described; maps showing world distribution of these deposits were included.[3]

[2]Although the title of the export class is "vanadium compounds," the material is almost all vanadium pentoxide.

[3]Fischer, R. P. Geology and Resources of Base-Metal Vanadate Deposits. U.S. Geol. Survey Prof. Paper 926-A, 1975, 14 pp.

——. Vanadium Resources in Titaniferous Magnetite Deposits. U.S. Geol. Survey Prof. Paper 926-B, 1975, 10 pp.

Hot-rolling behavior of austenite microalloyed with vanadium and nitrogen was investigated. The addition of vanadium and nitrogen to an aluminum-killed carbon-manganese-silicon steel altered the behavior of austenite during both deformation and holding subsequent to hot rolling in five different ways. The net result of the changes increased the number of heterogeneities present in the austenite prior to transformation. This caused an increase in the number of sites for the heterogeneous nucleation of ferrite and a concomitant decrease in the grain size of the transformation product.[4]

A new superconducting magnet system installed at the Japanese National Research Institute for Metals was developed through the combined use of columbium-tin superconductor tape manufactured by Intermagnetics General Corp. of the United States and vanadium-gallium superconductor tape developed by Vacuum Metallurgical Co. Ltd. of Japan. The magnet has produced a record magnetic field of 175,000 gauss.[5]

A patent was issued on a process for producing carbide addition agents including a new steel addition agent marketed as Ferrovanadium Carbide. This product, which contains about 70% vanadium and approximately equal percentages of carbon and iron, was introduced in the second half of 1976 by Reading Alloys, Inc., of Robesonia, Pa.[6]

A vanadium sludge, suitable for processing into vanadium metal, can be recovered from digestion solutions obtained in the processing of vanadium-containing bauxite or alunite into aluminum metal. The caustic solution is cooled to 40° to 65° C., and maintained at that temperature until a precipitate forms. The precipitate is removed, and the liquor is further cooled to 20° to 30° C. A precipitate of vanadium compounds is formed, the liquor is settled, and the second precipitate is separated as a sludge.[7]

The Vanadium International Technical Committee (Vanitec) continued to sponsor research projects on vanadium applications in 1976. Development of high-performance steels having high strength and impact resistance has been a major emphasis.

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[4] DeArdo, A. J., and E. L. Brown. Hot Rolling Behavior of Austenite Microalloyed With Vanadium and Nitrogen. J. of Metals, v. 29, No. 1, January 1977, pp. 26-29.

[5] Trade Times. Superconducting Magnet System Produces 175 KG. June 25, 1976.

[6] Perfect, F. H. (assigned to Reading Alloys, Inc.) U.S. Pat. 3,982,924, Sept. 28, 1976.

[7] Nasyrov, G. Z., and I. V. Ravdonikas (assigned to Vsesojuzny Nauchno-Issledovatelsky i Proektny Institut Aljuminievoi, Magnievoi i Elektrodni Promyshlennosti). Canadian Pat. 999,747, Nov. 16, 1976.

Vermiculite

By Stanley K. Haines[1]

Domestic production of crude vermiculite declined 8% from the 1975 level to 304,000 short tons. Output of exfoliated vermiculite remained the same as in 1975 at 235,000 short tons. The average value per ton of exfoliated vermiculite increased 5% to $161.82. Exfoliating plants processed both domestic and South African crude. The principal end uses were concrete aggregate; as premixes for acoustic, fireproofing, and other applications; and as loose-fill and block insulation. World production of crude vermiculite was 565,866 tons, a decrease of 2% from 1975.

Table 1.—Salient vermiculite statistics

(Thousand short tons and thousand dollars)

	1972	1973	1974	1975	1976
United States:					
Sold or used by producers:					
Crude	337	365	341	330	304
Value	$8,092	$9,464	$10,120	$13,761	$14,032
Average value per ton	$24.01	$25.93	$29.68	$41.70	$46.16
Exfoliated	247	293	275	235	235
Value	$24,777	$31,186	$30,916	$36,345	$38,055
Average Value per ton	$100.31	$106.44	$112.42	$154.66	$161.82
Exports to Canada	31	36	44	45	41
Imports from the Republic of South Africa	26	30	42	33	40
World: Production, crude	512	549	r557	r579	566

rRevised.

DOMESTIC PRODUCTION

Crude Vermiculite.—Output of vermiculite concentrate, commonly called crude, decreased from 330,000 tons in 1975 to 304,000 tons in 1976. The principal mining operations were W. R. Grace & Co.'s mine, in Libby, Mont., and beneficiation plants in Libby, Mont., and Enoree, S.C. In addition, Patterson Vermiculite Co. produced a small tonnage at Lanford, S.C.

Progress has been made by Virginia Vermiculite Co. in its efforts to begin mining in Louisa County, Va. In the latter part of 1976 the circuit court of Louisa County, Va., upheld the right of the board of supervisors to rezone the tracts of land containing vermiculite to allow mining. This decision is under appeal. The principal disputed issues are the damage mining would cause to the land (sight pollution) in light of the area's rural national historic landmark designation and the possible adverse effects caused by the presence of asbestos fibers in the ore.

Exfoliated Vermiculite.—The tonnage of exfoliated vermiculite sold or used remained about the same as in 1975. The five leading producing States were California, Florida, New Jersey, South Carolina, and Texas. W. R. Grace & Co., Construction Products Div., the principal producer of crude and exfoliated vermiculite, operated 30 exfoliating plants in 24 States. Crude vermiculite imported from the Republic of South Africa was exfoliated at 10 domestic

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plants. The sources of crude for domestic exfoliated vermiculite sold or used were Libby, Mont., 62%; South Carolina, 26%; and the Republic of South Africa, 12%.

Table 2.—Exfoliated vermiculite sold or used, by end use

(Short tons)

Use	1975	1976
Aggregates:		
Concrete	75,000	67,706
Plaster	4,000	3,099
Premixes[1]	38,000	39,448
Total	117,000	110,253
Insulation:		
Loose fill	39,000	39,053
Block	35,000	39,310
Packing	--	390
Total	74,000	78,753
Agriculture:		
Horticulture and soil conditioning	31,000	36,379
Fertilizer carrier	7,000	2,452
Total	38,000	38,831
Miscellaneous	6,000	7,334
Grand total	235,000	235,171

[1]Includes vermiculite used in premixes for acoustic and fireproofing purposes, decorative textures, moisture sealant, etc.

Table 3.—Vermiculite exfoliating plants in the United States in 1976

Company	State	County	Nearest city or town
J. P. Austin Assoc., Inc	Pennsylvania	Allegheny	Beaver Falls.
J. J. Brouk & Co., Inc	Missouri	St. Louis	St. Louis.
Carolina Wholesale Florists, Inc	North Carolina	Lee	Sanford.
Cleveland Builders Supply Co., Cleveland Gypsum Co. Div.	Ohio	Cuyahoga	Cleveland.
Diversified Insulation, Inc	Minnesota	Hennepin	Minneapolis.
W. R. Grace & Co., Construction Products Div.	Arizona	Maricopa	Phoenix.
	Arkansas	Pulaski	North Little Rock.
	California	Alameda	Newark.
	do	Los Angeles	Los Angeles.
	do	Orange	Santa Ana.
	Colorado	Denver	Denver.
	Florida	Broward	Pompano Beach.
	do	Duval	Jacksonville.
	do	Hillsborough	Tampa.
	Illinois	DuPage	West Chicago.
	Kentucky	Campbell	Newport.
	Louisiana	Orleans	New Orleans.
	Maryland	Prince Georges	Muirkirk.
	Massachusetts	Hampshire	Easthampton.
	Michigan	Wayne	Dearborn.
	Minnesota	Hennepin	Minneapolis.
	Missouri	St. Louis	St. Louis.
	Nebraska	Douglas	Omaha.
	New Jersey	Mercer	Trenton.
	New York	Cayuga	Weedsport.
	North Carolina	Guilford	High Point.
	Oklahoma	Oklahoma	Oklahoma City.
	Oregon	Multnomah	Portland.
	Pennsylvania	Lawrence	New Castle.
	South Carolina	Greenville	Kearney.
	do	do	Travellers Rest.
	Tennessee	Davidson	Nashville.
	Texas	Bexar	San Antonio.
	do	Dallas	Dallas.
	Wisconsin	Milwaukee	Milwaukee.
Hyzer & Lewellen	Pennsylvania	Bucks	Southampton.
International Vermiculite Co	Illinois	Macoupin	Girard.

Table 3.—Vermiculite exfoliating plants in the United States in 1976 —Continued

Company	State	County	Nearest city or town
Koos, Inc	Wisconsin	Kenosha	Kenosha.
La Habra Products, Inc	California	Orange	Anaheim.
MacArthur Co	Minnesota	Ramsey	St. Paul.
Mica Pellets, Inc.	Illinois	DeKalb	DeKalb.
Patterson Vermiculite Co	South Carolina	Laurens	Lanford.
Robinson Insulation Co	Montana	Cascade	Great Falls.
	North Dakota	Ward	Minot.
Schmelzer Sales Associates, Inc	Florida	Hillsborough	Tampa.
The Schundler Co	New Jersey	Middlesex	Metuchen.
Strong-Lite Products	Arkansas	Jefferson	Pine Bluff.
Supreme Perlite Co	Oregon	Multnomah	Portland.
Vermiculite of Hawaii, Inc	Hawaii	Honolulu	Honolulu.
Vermiculite-Intermountain, Inc	Utah	Salt Lake	Salt Lake City.
Vermiculite Products, Inc	Texas	Harris	Houston.

CONSUMPTION AND USES

Only minor changes in the end-use pattern occurred from 1975 to 1976. The principal end-use categories follow: Aggregates, 47%; insulation, 33%; agriculture, 17%; and miscellaneous, 3%. Additionally, 15,000 tons of crude vermiculite was consumed for various end uses without exfoliation.

PRICES

According to the Bureau of Mines canvass, the average value of domestic crude vermiculite increased from $41.70 per ton in 1975 to $46.16 per ton in 1976. The average value of exfoliated vermiculite increased 5% to $161.82. These values are f.o.b. mine or plant.

Engineering and Mining Journal quoted nominal yearend prices for crude vermiculite as follows: Per short ton, f.o.b. mine, domestic crude, $38 to $68, and c.i.f. Atlantic ports, Republic of South Africa crude, $60 to $80.

FOREIGN TRADE

Approximately 40,000 tons of crude vermiculite was imported duty-free into the United States from the Republic of South Africa, a 21% increase over that imported in 1975. A total of 40,850 tons of crude vermiculite was exported to Canada, principally from Libby, Mont.

WORLD REVIEW

Canada.—A total of 62,856 tons of crude vermiculite was imported in 1976, from the United States and the Republic of South Africa. The end-use pattern in 1975 follows: Loose insulation, 77%; insulating concrete, 4%; insulating plaster, 1%; agriculture, 9%; and miscellaneous (including fireproofing, underground pipe insulation, and barbecue base), 9%.[2]

South Africa, Republic of.—Total production of crude vermiculite increased over 7% in 1976 to 244,798 tons.

[2]Stonehouse, D.H. Lightweight Aggregates, 1975. Canada Dept. Energy, Mines, and Resources (Ottawa), 1976, 6 pp.

Table 4.—Vermiculite: World production, by country[1]

(Short tons)

Country[1]	1974	1975	1976[p]
Argentina	[r]4,216	[e]4,400	[e]4,400
Brazil[e]	5,000	5,000	5,000
Egypt[e]	50	50	50
India	3,109	2,400	3,644
Kenya	1,855	8,249	3,954
South Africa, Republic of	201,296	228,761	244,798
Tanzania	22	[e]20	[e]20
United States (sold or used by producers)	341,000	330,000	304,000
Total	[r]556,548	578,880	565,866

[e]Estimate. [p]Preliminary. [r]Revised.
[1]Excludes production by centrally planned economy countries.

Zinc

By V. Anthony Cammarota, Jr.[1]

As the rate of economic activity rose during 1976, mine and smelter production and imports of metal increased to satisfy a 23% increase in slab zinc consumption. Imports of slab zinc supplied about three-fifths of metal consumption. Imports of ores and concentrates fell, continuing the decline of 1975. Producer and consumer stocks at yearend 1976 were higher than at yearend 1975.

Mine production increased 3% compared with that of 1975, to 484,513 tons of recoverable zinc. Tennessee, Missouri, New York, Colorado, and Idaho accounted for 70% of the output. Eleven States showed increases and eight registered declines. Exploration activities were high in Tennessee and in Wisconsin, where Exxon Corp. announced the discovery of a massive sulfide deposit that could increase U.S. zinc reserves about 10%.

U.S. primary smelters operated at slightly more than 80% capacity in 1976 to produce 536,479 tons of slab zinc, a 13% increase compared with 1975 production. At yearend, National Zinc Co. started up a new electrolytic zinc plant to replace its horizontal retort plant. AMAX Inc. completed an extensive rehabilitation program at its electrolytic zinc plant. The New Jersey Zinc Co. broke ground for a 90,000-ton-per-year electrolytic zinc plant in Tennessee, which is expected to be operational in 1979. The Bunker Hill Co. completed construction of a 600-foot stack at its zinc plant in Idaho to meet pollution requirements.

Consumption of slab zinc increased to 1,134,141 tons. Increases in automobile production and housing starts of 27% and 25%, respectively, contributed to the recovery in consumption. A 3-month strike in the tire industry reduced consumption of zinc oxide.

Producer and consumer stocks were 181,952 tons on January 1, and after falling to 164,889 tons in March, the level gradually increased to finish the year at 215,047 tons.

In January, the price of Prime Western zinc was reduced 2 cents, to 37 cents per pound. In August, the producers raised the price to 39 to 40 cents per pound, but in October the companies rescinded the price increase. The 1976 average price was 37 cents per pound. The European producer price remained at 36.1 cents per pound. On the London Metal Exchange (LME), equivalent prices climbed in the first half of the year to an average of 35.9 cents per pound in June, but then underwent a steady decline to end the year at under 30 cents per pound.

On October 1, the Federal Preparedness Agency (FPA) approved a new goal for zinc of 1.313 million tons. The previous goal was 374,830 tons set in June. Achievement of the goal was to be a long-term program requiring a number of years.

With the exception of 1974, general imports of zinc in ores and concentrates have declined since 1970. In 1976, such imports were 97,115 tons, a 33% drop from those of 1975. General imports of slab zinc reached 714,489 tons in 1976, the highest level on record. Canada supplied 44% and Mexico, 9%. Major suppliers, who more than doubled shipments to the U.S. market compared with those of 1975, included Italy, Mexico, Yugoslavia, and Zaire. The People's Republic of China shipped 2,532 tons. The European Economic Community provided 19% of U.S. imports of zinc metal, compared with 17% in 1975.

Legislation and Government Programs.—On June 28, FPA raised the stockpile goal for zinc to 374,830 tons, which was the total uncommitted inventory at the time of the announcement. The previous goal was 202,700 tons. This action elimina-

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ted the excess of 172,130 tons of zinc that the General Services Administration (GSA) previously had available for disposal. In addition, GSA cancelled its agreement to sell zinc under long-term contracts with the producers. On October 1, FPA announced a new goal of 1,313,000 tons. At the end of the fiscal year, total inventory was 385,171 tons; uncommitted inventory was 374,830 tons, and 10,341 tons was committed to various Government agencies. The Director of FPA stated that stockpile planning was based on a 3-year emergency and that civilian needs were considered in the program.

The Environmental Protection Agency (EPA) suspended the daily average effluent limitation of 0.5 milligram of zinc per liter for ore mining and dressing facilities until April 30, 1977, to study additional data.[2]

A bill, H.R. 12883, was introduced in Congress on March 30 to suspend for a 2-year period the duty on zinc slab, but it did not pass.

Public Law 94-413, Electric and Hybrid Vehicles Research, Development, and Demonstration Act of 1976 was passed, the objective of which was to advance the technology of battery systems for electric vehicles through research and grants by the Energy Research and Development Administration (ERDA). Batteries using zinc have shown promise as practical high energy-density batteries for electric vehicles.

The International Lead and Zinc Study Group (ILZSG) held its 20th session in Geneva, Switzerland, November 4-12, to review developments in lead and zinc and consider projections for 1977. Producers curtailed zinc metal production in 1976, and were expected to continue to do so into 1977 in an attempt to avoid stock increases. Because France, Japan, and the United States have national stockpile policies, the need to review the impact of stockpiles on the market was expressed.

[2]Federal Register. Notice of Suspension, part 440. Ore Mining and Dressing Point Source Category. V. 41, No. 101, May 24, 1976, p. 21191.

———Notice of Further Suspension, part 440. Ore Mining and Dressing Point Source Category. V. 42, No. 11, Jan. 17, 1977, p. 3165.

Table 1.—Salient zinc statistics

	1972	1973	1974	1975	1976
United States:					
Production:					
Domestic ores, recoverable content ---- short tons	478,318	478,850	499,872	469,355	484,513
Value ---- thousands	$169,803	$197,861	$358,908	$366,097	$358,541
Slab zinc:					
From domestic ores ---- short tons	400,969	399,119	346,993	307,959	381,872
From foreign ores ---- do	232,211	184,360	208,195	130,092	116,983
From scrap ---- do	73,718	83,187	78,535	57,886	63,555
Total ----	706,898	666,666	633,723	495,937	562,410
Secondary zinc[1] ---- do	314,043	300,073	259,947	225,315	309,336
Exports of slab zinc ---- do	4,324	14,566	19,062	6,897	3,513
Imports (general):					
Ores (zinc content) ---- do	254,868	199,634	240,043	144,987	97,115
Slab zinc ---- do	522,612	592,046	539,538	380,437	714,489
Stocks, December 31:					
At producer plants ---- do	30,068	25,947	39,720	r74,676	93,893
At consumer plants ---- do	124,956	114,317	211,158	107,276	121,154
Government stockpile ---- do	949,583	677,009	391,600	385,714	385,192
Reprocessed GSA zinc[2] ---- do	80,403	109,333	42,850	3,442	--
Consumption:					
Slab zinc ---- do	1,418,349	1,503,938	1,287,696	925,330	1,134,141
All classes ---- do	1,844,023	1,931,925	1,673,013	1,231,815	1,541,890
Price: Prime Western cents per pound ---- (delivered)	17.75	20.66	35.95	38.96	37.01
World:					
Production:					
Mine ---- short tons	5,992,071	6,293,484	r6,371,590	r6,390,509	6,462,255
Smelter ---- do	5,655,754	5,876,535	r6,182,680	r5,592,453	5,978,484
Price: Prime Western grade, London cents per pound ----	17.13	38.55	56.13	33.76	32.38

[r]Revised.

[1]Excludes redistilled slab zinc.

[2]Included in total amount withdrawn from Government stockpile.

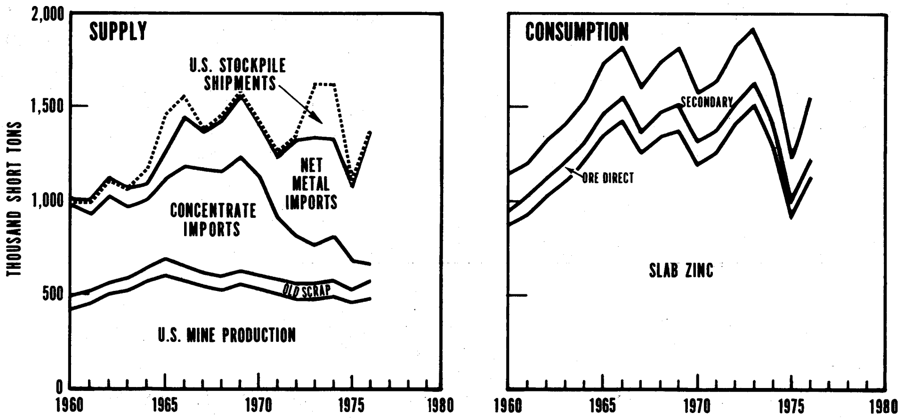

Figure 1.—Trends in supply and consumption in the United States.

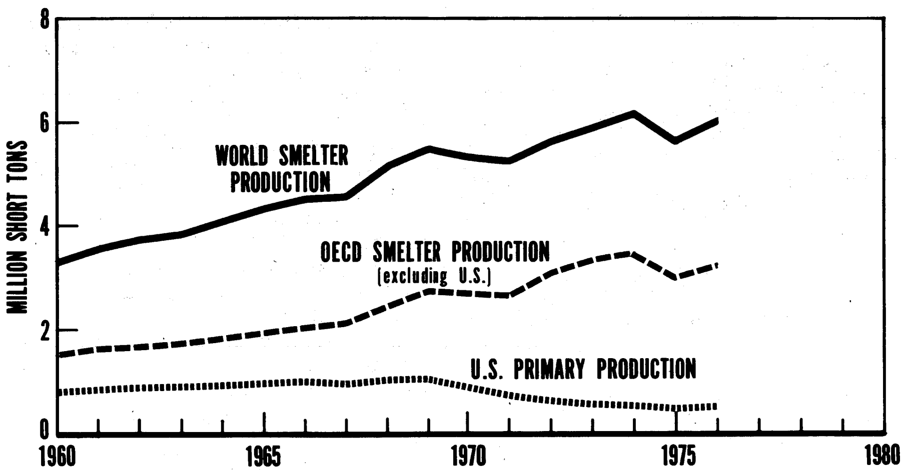

Figure 2.—Trends in United States, Organization for Economic Cooperation and Development (OECD), and world smelter production.

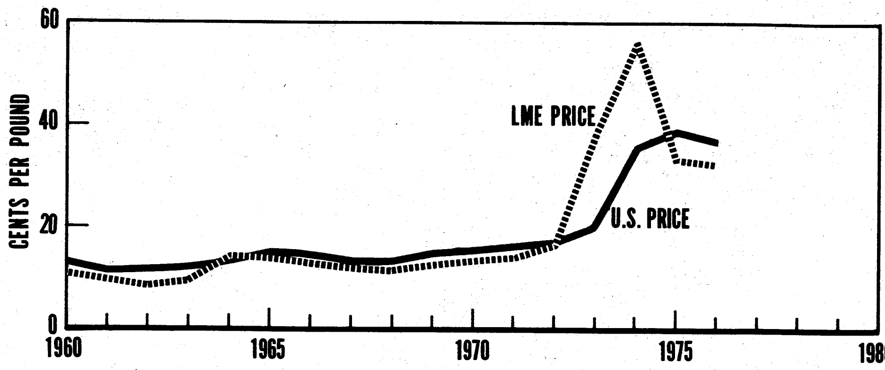

Figure 3.—Trends in average London Metal Exchange (LME) and domestic zinc prices.

DOMESTIC PRODUCTION

MINE PRODUCTION

U.S. mine production from 19 States was 484,513 tons, a 3% increase over that of 1975. The major producing States were Missouri and Tennessee, 17% each; New York, 15%; and Colorado and Idaho, 10% each. All of the major producing States, except New York and Tennessee, showed higher production than in 1975.

Table 5 shows sources of zinc production in 1976 according to ore type. Zinc ore accounted for 53% of the total zinc production, followed by zinc-lead ore, 21%; lead ore, 18%; copper-zinc and copper-lead-zinc ores, 7%; and other ores, 1%.

Table 6 shows the 25 leading U.S. zinc mines, which accounted for 89% of the recoverable domestic zinc mined in 1976. The five leading mines accounted for 41% of the total U.S. mine production.

Tennessee zinc mine production dropped 1% from that of 1975. Seven mines produced zinc from zinc ores, and one mine, Copperhill, produced zinc from copper-zinc ore. Jersey Minière Zinc Co., a 60-40 joint venture of The New Jersey Zinc Co. and Union Minière, S.A., continued development of the Gordonsville and Stonewall mines; New Jersey Zinc developed the Beaver Creek mine. The Elmwood mine attained full production status in 1976.

In east Tennessee, ASARCO Incorporated operated its zinc mines below design capacity throughout the year.[3] Production from the four mines was 42,700 tons of zinc, compared with 47,900 tons in 1975 and 56,400 tons in 1974. The zinc concentrate is used mainly for the production of zinc oxide at ASARCO's own plants in Ohio and Illinois. At the Young mill, construction began on a new ore concentrate drying and loading facility.

St. Joe Minerals Corp. formed a joint venture with a subsidiary of Freeport Minerals Co., for a 3-year, $5 million exploration and development project for zinc near Carthage, Tenn. ASARCO, Cominco American Inc., and NL Industries Inc. formed a joint venture to explore for zinc near Burkesville, Ky.

Zinc production as a coproduct from eight lead mines in Missouri increased 12% over that of 1975, as the State regained its position as the leading zinc producer. The Buick mine, owned 50% each by Homestake Mining Co. and AMAX Inc., mined 1,614,028 tons of ore with a lead content of 9.9% and zinc content of 3.9%. Ore reserves were given as 55 million tons assaying 7% lead and 2% zinc.[4] A program was begun to increase mine production to 1.8 million tons annually through improved techniques.

Production of zinc decreased 4% in New York, where St. Joe Minerals Corp. operated the Balmat and Edwards mines with a total capacity of 4,900 tons of ore per day. The Balmat mine retained its position as the Nation's largest zinc producer. The company stated that the decline in production resulted from mining lower grade ore.

[3] ASARCO Incorporated. 1976 Annual Report. Pp. 11, 18.
[4] Homestake Mining Co. 1976 Annual Report. P. 17.

In Colorado, zinc production from 13 mines was 50,621 tons, up 4% compared with that of 1975. Idarado Mining Co., owned 80.1% by Newmont Mining Co., treated 361,000 tons of ore grading 3.83% zinc, 2.40% lead, 0.49% copper, and 0.03 and 1.37 ounces of gold and silver per ton, respectively. Ore reserves were 3.5 million tons grading about 4.4% zinc. Resurrection Mining Co., wholly owned by Newmont Mining Corp., milled 200,000 tons of ore grading 9.26% zinc from the Leadville mine, which is managed by ASARCO. Ore reserves were 2 million tons grading 9.94% zinc.[5] Minerals Engineering Co. closed its Creede lead-zinc mine because of poor ore grade. Standard Metals Corp. increased mill capacity at its Sunnyside mine at Silverton to 1,000 tons of ore per day.

Zinc mine production was reported from 17 mines in Idaho, where production increased 14% over that of 1975. The Bunker Hill Co., a wholly owned subsidiary of Gulf Resources & Chemical Corp., increased production 10% at its Bunker Hill mine; production from the Star mine, owned 30% by Hecla Mining Co., remained unchanged. Proven and probable reserves of lead-zinc ore at these mines were 4.1 million tons containing 4.5% zinc and 3.3% lead.[6] Ore grade of the Star mine averaged 6.05% zinc, 5.61% lead, and 2.98 ounces of silver per ton, all of which were higher than 1975 levels.[7] Several veins contributed significantly to overall mine production and the preparation of new stoping areas assured adequate production for the next year. Most of the lateral development was at the 7,900-foot level, but the No. 4 shaft was deepened to the 8,100-foot level. Hecla's Lucky Friday mine produced 186,520 tons of ore, up 8% over 1975 production. Ore grade was 1.47% zinc, 10.91% lead, and 14.41 ounces of silver per ton. Operating costs increased about 5%, but were partially offset by improvements in productivity. Stope preparation on the 4,250-foot level was completed, along with station work on the 4,450-foot level, deepening of the main shaft to the 4,660-foot level, and installation of hoisting facilities. Ore reserves at yearend were 475,000 tons compared with 505,000 tons in 1975. Intermountain Mining Engineers, with 50% participation by U.S. Antimony Corp., rehabilitated the Nabob mine in the Pine Creek area of the Coeur d'Alene mining district and produced a small quantity of zinc.

Utah production of zinc from three mines was 22,481 tons, a 14% increase over that of 1975. Park City Ventures, a joint venture owned 60% by The Anaconda Company and 40% by ASARCO, mined 174,888 tons of ore at its leased lead-zinc-silver Ontario mine. In addition, Park City purchased 12,437 tons of ore from the Bingham district for milling. The milled ore contained 7.4% zinc, 5.2% lead, and 3.3 ounces of silver per ton. A 5-year development and exploration program was underway.[8]

Production was reported from one mine in Virginia, where production dropped 26%. Piedmont Mineral Associates, a joint venture of Callahan Mining Corp. (49%) and The New Jersey Zinc Co. (51%), suspended its underground drifting and drilling program at the Cofer mine at Mineral, Va. The company believes that high mining costs may make the deposit uneconomical.

Washington reported a significant increase in production compared with that of 1975 from its four mines. Ore production at the Pend Oreille mine increased about 25% over that of 1975. Exploration for additional reserves continued.[9]

In Maine, the Blue Hill joint venture, 60% owned by Kerr Addison, Ltd., and 40% by Kerramerican, Inc., was the only zinc producer. Mine production of recoverable zinc was 7,810 tons, a 6% decline from that of 1975. Total ore mined was 176,100 tons grading 1.2% copper and 5.1% zinc.[10] Because of zinc smelter cutbacks, 10,700 tons of concentrate was stockpiled. Minable ore reserves of 219,000 tons grading 3.2% zinc were down 58% from those of 1975. About 186,000 tons of ore reserves in the Carlton area, which were included in the 1975 figure, were deleted from the reserves figure given in 1976, because they were considered uneconomic.

Mine production of zinc from two mines in Southwest Wisconsin increased slightly compared with that of 1975. Exxon Company, U.S.A., a division of Exxon Corp., announced the discovery of a massive sulfide deposit near Crandon in northern Wisconsin containing 70 million tons of ore grading 5% zinc, 1% copper, and lesser amounts of lead, gold, and silver.

Arizona zinc production from nine mines was 9,501 tons, up 10% over that of 1975. Cyprus Mines Corp. produced 90,278 tons of ore grading 13% zinc and 3.54% copper

[5]Newmont Mining Corp. 1976 Annual Report. Pp. 5-6.
[6]Gulf Resources & Chemical Corp. 1976 Annual Report. Pp. 11-12
[7]Hecla Mining Co. 1976 Annual Report. Pp. 6-7.
[8]United Park City Mines Co. 1976 Annual Report. Pp. 5-6.
[9]Work cited in footnote 6.
[10]Kerr Addison Mines Ltd. 1976 Annual Report. P. 10.

from its Cyprus Bruce mine. Proven reserves were established at 128,000 tons. Exploratory underground drilling uncovered no significant mineralization.[11]

Production in Nevada declined 74% with the closing of the Pan American mine near Pioche early in the year. Later, The Bunker Hill Co. acquired an interest in the mine and Caselton concentrator 16 miles away. If exploration and development work proved sufficient reserves, full-scale mining operations were to begin in 1977.

SMELTER AND REFINERY PRODUCTION

U.S. slab zinc production at 6 primary plants and 13 secondary plants was 562,410 tons in 1976, an increase of 13% over that of 1975. Primary and secondary metal production at primary plants was 536,479 tons, for a capacity utilization of slightly more than 80%. The portion of domestic slab zinc production from domestic ores was 68%; from foreign ore, 21%; and scrap, 11%. Zinc produced from foreign ore decreased 10% from that of 1975, while production from domestic ore increased 24%, and from scrap, 10%. Producer stocks at the smelter increased from 74,676 tons to 93,893 tons during the year.

Primary slab zinc produced at electrolytic refineries increased 11% compared with that of 1975 and was 46% of the total slab zinc produced. Zinc produced at retort plants was up 17% and comprised 43% of the total. Redistilled slab zinc from secondary materials produced at primary smelters increased 8% and contributed 7% of the total, and redistilled slab zinc at secondary smelters increased 13% and comprised 4% of the total. Distribution of slab zinc production, by grades was Prime Western, 48%; Special High Grade, 42%; High Grade, 5%; Intermediate, 4%; and Brass Special, 1%.

The new 350-ton-per-day acid plant at ASARCO's Corpus Christi, Tex., electrolytic zinc plant was almost completed by yearend. The company planned to modernize the leaching and electrolyte purification systems, which would lead to increased capacity and operating efficiency. ASARCO's plans for a 180,000-ton-per-year zinc plant in Kentucky advanced when M.I.M. Holdings Ltd. of Australia, owned 49% by ASARCO, agreed to participate in the venture and supply concentrates in proportion to its ownership interest.

National Zinc Co. completed construction of its Bartlesville, Okla., electrolytic plant in mid-1976. The new $40 million plant, rated at an annual capacity of 56,000 tons of slab zinc, replaced the old horizontal retort smelter of similar capacity at the same location. However, a 3-month strike delayed startup until December. The new facility makes use of the existing roaster and sulfuric acid plant. The company intends to debase its Special High Grade zinc product to Prime Western and Continuous Galvanizing Grade. The plant was expected to meet air and water pollution standards that were a major factor in the decision to replace the retort smelter.

AMAX Zinc co., Inc., completed modernization of its Sauget, Ill., electrolytic zinc plant with the installation of a new water treatment facility. The plant produced 70,031 tons of zinc compared with 58,060 tons in 1975.[12]

Bunker Hill produced 100,000 tons of slab zinc, a 7,000-ton increase compared with 1975 production. The company filed a petition in late 1975 for a judicial review of the EPA decision to disapprove the Idaho plan for control of sulfur dioxide emissions. Bunker Hill began a long term program of revegetation of 18,000 acres near the Kellogg plant.[13] Bunker Hill and NL Industries Inc. terminated their toll agreement on December 31, 1975, and Bunker Hill Sales Co., Inc., was formed in January to handle sales of zinc metal from the Kellogg plant.

The New Jersey Zinc Co. and Union Minière, S.A., of Belgium, broke ground for a $97 million, 90,000-ton-per-year zinc plant at Clarksville, Tenn., scheduled for completion in early 1979. Concentrate from the Tennessee mines being developed by the partnership will be transported to the plant by river barge.

St. Joe Minerals Corp. was building a zinc dust facility at its Monaca, Pa., smelter that will have an initial capacity of 6,000 tons per year.[14] In addition, the company planned to spend about $50 million for pollution control at the zinc smelter. Zinc concentrates from the Balmat and Edwards mines comprise about one-half of the smelter feed,

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[11]Cyprus Mines Corp. 1976 Annual Report. P. 7.
[12]AMAX Inc. 1976 Annual Report. P. 19.
[13]Pages 11-13 of work cited in footnote 6.
[14]St. Joe Minerals Corp. 1976 Annual Report. Pp. 10, 19.

with the balance being obtained from other domestic and foreign suppliers. The company stated that energy costs for producing zinc had increased 145% since 1974.

A contract was awarded to St. Joe for the design, construction, and operation of a facility to test the U.S. Bureau of Mines citrate process for removing sulfur from stack emissions. The test facility will be built at the powerplant that supplies electricity to its electrothermic smelter. St. Joe owns the coal mines which supply the powerplant.

Secondary Zinc Smelters.—Zinc recovered from zinc-bearing scrap was 372,891 tons in 1976, a 32% increase compared with that recovered in 1975. Zinc-base scrap accounted for 59% of the total compared with 58% in 1975, while zinc recovered from copper-base scrap was 41%, the same as in 1975. Recovery from both new and old scrap was higher than that in 1975, with old scrap accounting for 26% in 1976 of the total zinc recovered from scrap, compared with 27% in 1975. Of the total zinc recovered from scrap, 29% was recovered as zinc metal, 58% as alloys, mostly brass and bronze, and 13% as compounds, mostly zinc oxide.

Slag-Fuming Plants.—Hot and cold lead blast furnace slags and residues were processed by slag-fuming plants to produce zinc oxide fume. The oxide was either sold and used as oxide or sent to smelters and refineries for processing into metallic zinc. Three plants operated in 1976 as in 1975: ASARCO at El Paso, Tex., and East Helena, Mont., and Bunker Hill, at Kellogg, Idaho.

Byproduct Sulfuric Acid.—In 1976, seven plants roasted zinc sulfide concentrates and produced sulfuric acid, with one plant operating solely to produce calcine for processing to zinc oxide or slab zinc. In 1976, production of byproduct sulfuric acid from zinc plants was 799,773 tons, up from 711,769 tons produced in 1975.

Zinc Dust.—Production of zinc dust increased 10% over that of 1975 to 46,358 tons in 1976. Zinc dust from distilled scrap accounted for 40,471 tons.

CONSUMPTION AND USES

In 1976, slab zinc consumption increased 23% over that of 1975 as a result of the economic recovery. Domestic consumption of slab zinc was 1,134,141 tons in 1976. The zinc content of the ore used directly in galvanizing or compounds was 101,241 tons, up from 82,732 tons in 1975. The zinc content of secondary materials to make alloys, zinc dust, and compounds was 306,508 tons, up from 223,753 tons in 1975. Total consumption of zinc for all classes was 1,541,890 tons, an increase of 25% over that of 1975.

Slab zinc used for galvanizing accounted for 433,083 tons (38%); zinc-base alloys, 427,031 tons (38%); brass products, 166,244 tons (15%); zinc oxide, 39,027 tons (3%); rolled zinc, 29,859 tons (3%); and other, 38,897 tons (3%).

Slab zinc consumption distributed by grade was Special High Grade, 551,270 tons (49%); High Grade, 111,407 tons (10%); Intermediate, 23,204 tons (2%); Brass Special, 104,460 tons (9%); Prime Western, 342,538 tons (30%); and Remelt, 1,262 tons (0.1%). Consumption of all grades of slab zinc increased over that of 1975. The most significant increases were 34% for High Grade and 26% for Special High Grade zinc, while the gain for Prime Western was 11%.

Slab zinc consumed at rolling mills was 29,859 tons in 1976, an increase of 9% over that of 1975. Production of rolled zinc products increased 13% to 29,874 tons. Strip and foil accounted for 75%. Exports of wrought zinc increased 39% to 2,271 tons and imports decreased from 236 tons to 209 tons. Production of rolled zinc from scrap was 24,630 tons in 1976, yielding a total of 54,504 tons of rolled zinc during the year, compared with 49,878 tons in 1975.

The leading zinc-consuming States in 1976 were Illinois with 155,357 tons (14%); Ohio, 152,814 tons (13%); Pennsylvania, 124,991 tons (11%); New York, 119,542 tons, (11%); Indiana, 117,070 tons (10%); and Michigan, 113,882 tons (10%). These six States accounted for 69% of the slab zinc consumed, excluding remelt zinc. Ohio ranked highest in galvanizing and Michigan was the leader in diecasting.

The Zinc Institute Inc. conducted a survey of 446 diecasters to determine the market distribution of the 416,450 tons of zinc consumed by these companies in 1976. The results showed that automotive components accounted for 49.6% of the total; builders' hardware, 21%; domestic appliances, 7.3%; industrial, agricultural, and commercial machinery, 5.7%; electrical components, 8.9%; sporting goods and toys, 2.4%; scientific and professional equipment, 1.3%; sound and television equipment, 1.2% and miscellaneous, 2.6%.

ZINC PIGMENTS AND SALTS

Production.—Production of zinc oxide in 1976, at 194,481 tons, increased 18% compared with that of 1975. Shipments were 2% higher than production. The source of domestic zinc oxide production was 59% from ore and concentrate (American process), 24% from slab zinc (French process), and 17% from secondary material. Total French process zinc oxide, including that from remelt and scrap, was 31% of the total. Lead-free zinc oxide was produced at 13 plants in the United States and leaded zinc oxide was produced at 1 plant.

Zinc sulfate production, at 34,681 tons from nine companies, showed an increase of 48% as Madison Industries Inc. became a significant supplier of zinc chemicals. Zinc sulfate production came from secondary material and from ore or intermediate products. Zinc chloride production from five companies was 15,241 tons, 11,457 tons of which was shipped.

St. Joe Minerals produced 52,246 tons of zinc oxide, up 11% over that of 1975, and ASARCO, with plants at Columbus, Ohio, and Hillsboro, Ill., produced 34,100 tons, up 34% over 1975. New Jersey Zinc also produced zinc oxide from ores or concentrates. Other major zinc oxide producers, such as the Eagle-Picher Industries, Inc., Hillsboro, Ill., plant and the Sherwin-Williams Co., Coffeyville, Kans., plant, used calcines, fume, and secondary materials as raw materials. ASARCO, New Jersey Zinc, and St. Joe were the three producers of French process zinc oxide from primary slab zinc.

Consumption and Uses.—The apparent consumption of zinc oxide increased 18% in 1976 to about 213,000 tons. Analysis of domestic shipments by industry usage showed the largest consumers to be the rubber industry with 53% of the total; chemicals, 17%; photocopying, 12%; and paints, 8%. The use of zinc oxide increased in all categories except photocopying, which declined 2% and other, down 29%. Among miscellaneous uses, zinc oxide was used in floor coverings, fabrics, lubricants, plastics, and rayon manufacturing. Agriculture was the chief use for zinc sulfate with lesser amounts assigned to rayon, flotation reagents, and chemicals. Leaded zinc oxide was used in rubber, and lithopone was used mainly in paints. Most of the zinc chloride was used in soldering fluxes and batteries.

Prices.—Effective January 5, U.S. producers lowered prices 1 cent per pound for zinc oxide. Prices quoted were 39 to 40 cents per pound for American process zinc oxide, 40.5 cents for French process, 43 to 44 cents for electrophotographic grade, and 35.5 cents for leaded zinc oxide. St. Joe increased prices 3 cents per pound in July to 42 cents for American process and 43.5 cents for French process. The price for electrophotographic grade climbed to 45 to 46 cents per pound and leaded zinc oxide was quoted at 39 cents. New Jersey Zinc also increased its zinc oxide prices to the same level, citing higher labor, production, and energy costs as the reason. On October 13, with the reduction in the price of zinc, the prices of various grades of zinc oxide were also reduced. List prices were 40 cents per pound for American process, lead-free, pigment grade, 41.5 cents for French process, regular, 43 to 44 cents for electrophotographic grade, and 38 cents for zinc oxide, leaded, 12%. The price of zinc sulfate, granular monohydrate industrial, 36% zinc, bags in car load lots, was reported as $24.00 to $26.50 per 100 pounds in December, unchanged from a year earlier. The price of technical grade zinc chloride, 50% solution, in tank car quantities, was $15.25 per 100 pounds during the year.

Foreign Trade.—Exports of zinc oxide increased 56% over those of 1975 to 4,838 tons, of which 4,261 tons was pigment grade. Canada and Mexico received 70% of the total. Lithopone exports decreased by 15% to 779 tons. Imports of all classes of zinc compounds increased in 1976 to a total of 27,969 tons, a 52% gain. As in 1975, zinc oxide was the major component of imports of zinc compounds. Mexico and Canada supplied 94% of the zinc oxide; other European Economic Community countries contributed most of the remainder.

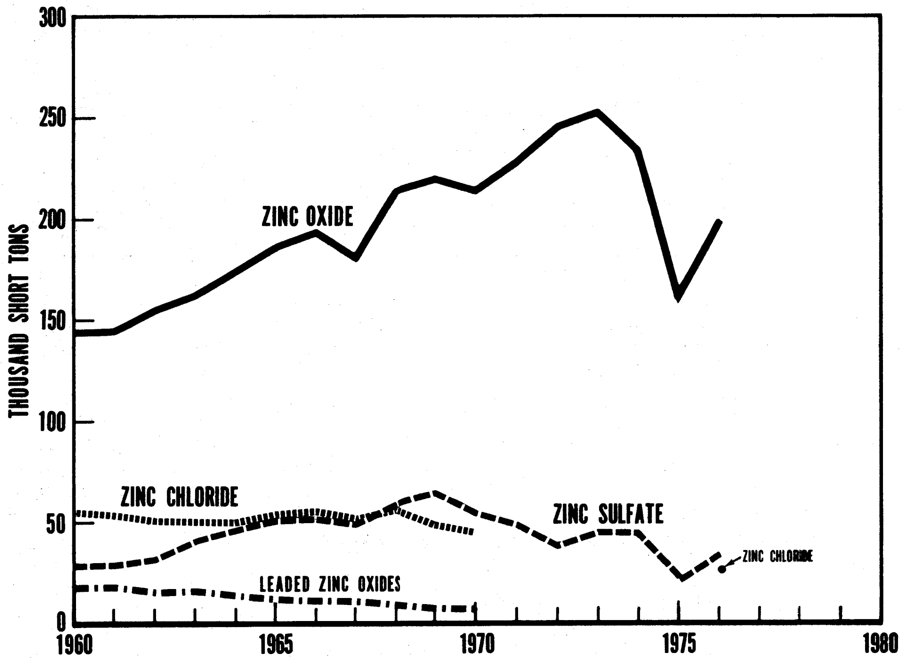

Figure 4.—Trends in shipment of zinc pigments.

STOCKS

Producer Stocks.—Stocks of slab zinc at producer plants at the beginning of the year were 74,676 tons, increasing to 93,893 tons by yearend. The Zinc Institute Inc. reported that producer stocks at smelters dropped to 59,092 at the end of September, but by yearend had climbed to the monthly high for the year.

Consumer Stocks.—Slab zinc inventories at consumer plants were 107,276 tons at the beginning of the year, but by yearend consumer stocks had risen to 121,154 tons. In the January to October period, consumer stocks gradually climbed to about 136,000 tons, but fell off in the last 2 months.

PRICES

ASARCO led a price cut of 1.5 to 2 cents per pound of zinc on January 5 to 37 cents for Prime Western, 37.5 cents for Special High Grade and Continuous Galvanizing Grade, and 37.25 cents for Controlled Lead Grade. Competition from imports was given as the major reason for the decline. Other domestic producers also cut prices as did foreign producers selling zinc in the United States. In April, speculation arose of a price increase, but a clause in the agreement between GSA and producers on stockpile purchases that would have allowed the opening of a closed quarter if the price of zinc increased dampened the possibility. In July, when GSA could no longer sell zinc because FPA raised the stockpile goal, the possibility of producers being required to buy stockpile metal if prices were increased was removed. Effective August 3, Texasgulf Inc. increased its U.S. price by 3 cents per pound across the board. St. Joe, the first U.S. company to follow, quoted prices of 40 cents for Prime Western and High Grade, 40.25 cents for Controlled Lead, and 40.5 cents for Continuous Galvanizing Grade. ASARCO sold its zinc on a Metals Week weighted average of Prime Western metal.

Bunker Hill increased its Prime Western price by 2 cents per pound, as did ASARCO and National Zinc at the end of August. By September 1 a two-tier price was in effect for Prime Western, High Grade, and Special High Grade zinc. By mid-October the depressed zinc market forced a price cut of 3 cents, initiated by AMAX, which most companies made retroactive to the August increase date. Discounting, price protection, and a weak LME price led to the drop. The average price of Prime Western zinc in 1976 was 37.01 cents per pound.

In May the U.S. Department of Justice opened an antitrust investigation into pricing practices abroad. The Department requested information and documents on the European producer price, agreements, and sales receipts. Later in the year U.S. producers were queried.

On the LME, zinc prices varied widely during the year. The price rose from 31 cents per pound in January to 37.1 cents in April, higher than the prevailing U.S. price, on speculation of a price increase. In May a voluntary ban on LME speculative zinc accounts, less expectation of a U.S. price increase, and the first arrivals of significant quantities of North Korean zinc led to a decline to 33.6 cents per pound in June. The turnover of 483,170 tons of zinc on the LME in the first 4 months was 58% above that of the same period in 1975. Lifting of the LME trading ban and news of GSA contract cancellations in the United States started a rally to more than 36 cents in midsummer. Despite the U.S. price increase in August, the LME reportedly was more influenced by arrivals of North Korean zinc and the accumulation of over 100,000 tons of LME stocks. By November the price had fallen to 26 cents, but recovered by yearend to almost 30 cents because producers supported the price by allowing customers to purchase part of their needs from LME stocks through the producer agent.

FOREIGN TRADE

Exports of unwrought zinc and alloys were 5,106 tons in 1976, a 47% decrease from those of 1975. The Netherlands received 56% of the exports; Canada, 19%; and Saudi Arabia, 7%. Wrought zinc and zinc alloy exports were 9,998 tons in 1976, of which 48% went to Belgium-Luxembourg and 33% to Canada.

Exports of lead and zinc ores and concentrates, which have been reported as a combined category since 1965, are shown in table 32, and a 3-year breakdown of recipient countries is given in table 33. Exports have increased from 434 tons (gross weight) in 1965 to 148,787 tons in 1976.

General imports of zinc in ore were 97,115 tons in 1976, a decrease of 33% from those of 1975. Canada supplied 72% and Honduras 17%. Imports from Peru fell 84%. General imports of zinc metal were 714,489 tons, an increase of 88% over those of 1975. Canada supplied 44% of the total; Mexico, 9%; and West Germany, 7%. Other leading suppliers, in decreasing order, were Zaire, Belgium-Luxembourg, Australia, and Finland. Countries that more than doubled shipments to the U.S. market over those of 1975 included France, West Germany, Italy, Mexico, Poland, the People's Republic of China, Yugoslavia, and Zaire; together, these countries provided 31% of the total. In 1976, developed market economy countries provided 78% of the total, developing market economy countries, 17%; and centrally planned economy countries, 5%; compared with 85%, 13%, and 2%, respectively, in 1975.

Imports of concentrate for consumption were 155,803 tons in 1976, a decrease of 428,544 tons from those of 1975 when large tonnages were withdrawn from bonded warehouses after removal of the tariff on concentrates. Metal imports for consumption were 695,131 tons in 1976, 85% more than in 1975.

The U.S. Department of the Treasury investigated charges by U.S. zinc producers that a tax rebate allowed by Spanish tax laws subsidized zinc exports from that country. A finding against Spain could lead to the imposition of countervailing duties by the United States.

There were no changes in the basic tariff rates in 1976 for slab zinc at 0.7 cent per pound, and zinc dust at 0.3 cent per pound. The duty rate for unwrought alloys of zinc, which include diecasting alloys, was 19% ad valorem.

Table 2.—Principal Canadian zinc producers in 1976

Company	Mine	Mill capacity (thousand tons per day)	Recoverable metals	Ore milled (thousand tons)	Zinc content of ore percent	Reserves: Ore (thousand tons)	Reserves: Zinc (percent)
British Columbia:							
Cominco Ltd	Sullivan	8,000	Zinc, lead	[1]2,342	3.9	57,000	[2]10.9
Do	H. B	1,200	do	412	3.8		
Western Mines Ltd	Lynx and Myra	1,100	Zinc, lead, copper, silver.	297	7.7	1,700	7.9
Kam Kotia Mines Ltd	Silmonac	120	Zinc, lead, silver	18	4.8	NA	NA
Manitoba:							
Hudson Bay Mining & Smelting Co., Ltd.	Flin Flon-Snow Lake area.	8,500	Zinc, lead, gold, silver, copper.	1,562	2.7	[3]17,536	2.9
Sherritt Gordon Mines, Ltd	Fox	3,000	Zinc, copper	832	1.6	7,800	2.1
Do	Ruttan	10,000	do	2,661	2.1	32,050	1.3
New Brunswick:							
Brunswick Mining & Smelting Corp. Ltd.	Bathurst	10,000	Zinc, lead, silver, copper.	2,477	7.2	106,500	9.2
Heath Steele Mines Ltd	Newcastle	4,000	do	1,160	4.5	31,900	4.4
Nigadoo River Mines Ltd	Robertville	1,100	do	219	2.6	250	2.9
Newfoundland:							
ASARCO Incorporated	Buchans	1,250	Zinc, lead, silver	208	10.7	600	10.5
Teck Corp. Ltd.[4]	Daniel's Harbor	1,500	Zinc	508	8.1	3,800	8.9
Ontario:							
Texasgulf Canada Ltd	Kidd Creek	10,000	Zinc, lead, silver, copper.	3,574	8.1	85,000	6.1
Selco Mining Corp. Ltd	South Bay	500	Zinc, copper	180	10.4	678	10.8
Sturgeon Lake Mines Ltd	Sturgeon Lake	1,200	Zinc, lead, copper, silver.	416	9.6	1,360	9.1
Mattabi Mines Ltd	Mattabi	3,000	do	1,066	8.1	6,500	6.9
Noranda Mines Ltd	Geco Division	5,000	do	1,686	2.6	27,500	3.6
Willroy Mines Ltd	Manitouwadge division.	1,600	do	343	3.7	760	4.4
Quebec:							
Falconbridge Copper Ltd	Lake Dufault	1,500	Zinc, copper	505	3.5	1,410	4.8
Manitou-Barvue Mines Ltd.[5]	Manitou	1,600	Zinc, lead, silver	107	3.1	740	[6]2.3
Mattagami Lake Mines Ltd	Matagami	3,850	Zinc, copper, silver, gold.	1,226	7.3	9,610	7.1
Orchan Mines Ltd	Garon Lake	1,900	Zinc, copper, silver	468	6.7	[7]2,620	6.3
Sullivan Mining Group Ltd	Stratford Centre[8]	1,400	do	228	2.3	[8]820	1.7
Société Miniére Louvem Inc	Louvem	([9])	Zinc, copper	--	6.0	1,900	7.3
Lemoine Mines Ltd	Lemoine	300	do	107	10.4	580	9.6

See footnotes at end of table.

Table 2.—Principal Canadian zinc producers in 1976 —Continued

Company	Mine	Mill capacity (thousand tons per day)	Recoverable metals	Ore milled (thousand tons)	Zinc content of ore percent	Reserves: Ore (thousand tons)	Reserves: Zinc (percent)
Northwest Territories:							
Pine Point Mines Ltd	Pine Point	10,000	Zinc, lead	3,773	5.3	36,200	5.4
Yukon Territory:							
Cyprus Anvil Mining Corp	Faro	10,000	Zinc, lead, silver	1,675	[2]8.1	44,700	[2]8.6
United Keno Hill Mines Ltd	Elsa, Husky, No Cash	500	do	76	NA	182	1.2

[e]Estimate. NA Not available.
[1]Ore produced.
[2]Combined lead and zinc content.
[3]Recoverable.
[4]Fiscal year ending Sept. 30, 1976.
[5]Mine, mill, and concentrator merged into Société Miniére Louvem, Inc. on Aug. 31, 1976.
[6]After dilution.
[7]Includes the Norita Division.
[8]Milled mine output from Cupra, D'Estrie, and Clinton mines.
[9]Ore milled by Manitou-Barvue Mines Ltd.

Source: Company annual reports and Zinc preprint chapter, 1976 Canadian Minerals Yearbook, Department of Energy, Mines and Resources, Ottawa, Canada.

WORLD REVIEW

Preliminary data from the World Bureau of Metal Statistics[15] indicated that the world consumption of slab zinc increased 14% over that of 1975. Western Europe gained 17%; Australia, 8%; Japan, 28%; and centrally planned economy (CPE) countries, 4%; but Canadian consumption fell 10%. Bureau of Mines data showed world mine production up 1%, and slab zinc production up 7%, over 1975 levels. In mining, increases were especially noted in Brazil, France, Greece, Sweden, the Republic of South Africa, and the Republic of Korea; Australia, Canada, Mexico, Zaire, and Zambia made significant cutbacks. Mine production in the CPE countries gained 4%. Increases in smelter production were prominent in Australia, Canada, France, Japan, Spain, the United States, and the U.S.S.R. Production in Zambia fell because of mechanical problems at the smelter. Production in the United Kingdom declined owing to a labor strike at the Avonmouth smelter that did not end until March. Zinc metal production in CPE countries increased 2% over that of 1975.

Stocks in LME warehouses increased from 80,772 tons on January 3 to 98,299 tons by yearend. Most of the increase occurred from April through November, with a falloff in the last month. Producer stocks worldwide decreased 7% to about 763,000 tons during the year. European producers held about 257,000 tons; Japanese producers, about 201,000 tons; and other countries, the remainder. Consumer stocks were about 171,000 tons.[16]

World mine capacity increased 322,000 tons of zinc per year with the opening of the Huari-Huari mine (30,000 tons) in Bolivia, four new mines or expansions in Canada (108,000 tons), the LaPlata mine (3,000 tons) in Ecuador, the Noailhac-Saint Salvy mine (23,000 tons) in France, the Balaria mine (22,000 tons) in India, six mines (66,000 tons) in Peru, the Stekenjokk mine (13,000 tons) in Sweden, the Zamanti mine (44,000 tons) in Turkey, and the Brskoro mine (23,000 tons) in Yugoslavia. Two mines closed, one in Canada and one in Australia.

World smelter capacity for slab zinc increased slightly to 7.545 million tons per year. A new 44,000-ton-per-year electrolytic plant was brought onstream by CINKUR (Zinc and Lead Metal Industry, Inc.) Turkey. The Ghazaouet smelter in Algeria reached its full capacity of 40,000 tons, and Española del Zinc, S.A., increased capacity of its Cartagena smelter in Spain by 33,000 tons. In Poland, a capacity reduction of 29,000 tons took place at the Katowice horizontal retort plant. An agreement was reached between the Thai Government and Thai Zinc Co., Ltd. on the construction of a smelter, but formal approval had not been received by yearend.

Australia.—Zinc production from the Mount Isa mine in Queensland, operated by Mount Isa Mines Ltd., was 123,000 tons, down from 126,000 tons in 1975. Reserves at the mine were 61 million tons of ore assaying 6.5% zinc. Development of the new Hilton lead-zinc-silver mine was scaled down, where reserves are 41 million tons of ore grading 9.6% zinc and 7.7% lead. The company planned to begin pilot operations at the McArthur River lead-zinc-silver deposit in the Northern Territory.[17] The ore body contains proven reserves of 210 million tons of ore assaying 9.5% zinc.

In late 1976 North Broken Hill Holdings Ltd. became the holding company for the operating subsidiary North Broken Hill Ltd. During the fiscal year the company mined 491,511 tons of ore grading 9.79% zinc, to produce 83,610 tons of zinc concentrate assaying 52.32% with a mill recovery rate of 91.2%. The concentrates are smelted in Australia.[18] At the West Coast mine in Tasmania, EZ Industries Ltd. produced 71,509 tons of zinc from ore grading 12.6% zinc. The company also treated zinc-rich tailings at the site. Reserves were given as 8.8 million tons of ore grading about 17% zinc. Mining of the willemite (zinc silicate) ore deposit at Beltana, South Australia, continued, with 5,896 tons being shipped to the Risdon smelter and 23,346 tons being exported. However, the mine was placed on standby pending new contracts. Exploration of the Elura prospect near Cobar indicated a resource of about 24 million tons of lead-zinc-silver ore grading about 8.6% zinc. The company planned to sink a shaft to obtain ore samples for pilot plant testing.[19]

EZ Industries produced 151,303 tons of zinc metal and 7,674 tons of zinc dust from

[15] World Bureau of Metal Statistics (London). World Metal Statistics. V. 29, No. 5, August 1977, pp. 91-93.

[16] International Lead and Zinc Study Group. Lead and Zinc Statistics. Monthly Bulletin, v. 17, No. 6, June 1977, pp. 6-7, 23.

[17] M.I.M. Holdings Ltd. 1976 Annual Report. Pp. 4, 7, 30.

[18] North Broken Hill Holdings Ltd. 1977 Annual Report. P. 10.

[19] EZ Industries Ltd. 1976 Annual Report. Pp. 7-9, 14.

its Risdon smelter in the fiscal year ending June 30, 1976. Production at the Cockle Creek smelter of Sulfide Corporation Pty. Ltd., which operated at about 65% capacity most of the year, was 54,000 tons. Pollution control equipment was installed at a cost of $2.4 million. The Broken Hill Associated Smelters Pty. Ltd. embarked on a $9 million pollution control program at its Port Pirie smelter, which produced 34,000 tons of zinc in 1975.

St. Joe Minerals, Phelps Dodge Corp., and Australian Mining and Smelting will each have a one-third interest in the Woodlawn zinc-lead-silver-copper deposit in New South Wales. The deposit is estimated to contain 10 million tons of ore averaging 9.1% zinc, 3.5% lead, 1.8% copper, and 1.8 ounces of silver per ton. The cost for the open pit mine and mill, which is to be operational in 1978, is $88 million.

Minerals, Mining and Metallurgy closed its South mine at Broken Hill, New South Wales, because of lower ore grades and higher costs, but retreatment of old tailings will continue.

Bolivia.—Corporación Minera de Bolivia (COMIBOL) produced 37,529 tons of zinc in 1976, up from 34,963 tons in 1975. A new 400-ton-per-day plant was installed at the Colquiri mine, and a second concentration plant to treat the marmatitic ore was under construction. The Matilde mine, the largest in Bolivia with a mill capacity of 1,100 tons per day, produced 23,145 tons of zinc. A new shaft was being sunk that was expected to increase production significantly in 1977. Production began from New Jersey Zinc's Huari-Huari mine, where both silver and cadmium are found in the ore.

Canada.—Mine output, at 1,321,500 tons, was 3% lower than that of 1975. About 38% came from zinc ores, 13% from copper ores, and the balance from mixed ores. Depleted reserves forced the closure of one mine, but three new mines came into production. Mill capacity at yearend was 103,220 tons of ore per day. The Sullivan Mining Group Ltd. planned to close the Cupra and D'Estrie mines in early 1977, which had a combined capacity of 1,400 tons per day.[20]

The leading producing provinces were Ontario with 31% of the total zinc production, followed by New Brunswick, 17%; Northwest Territories, 14%; Quebec, 12%; and British Columbia, 11%. Data for the principal producing mines are given in table 2. Slab zinc output was 521,200 tons, up 11% over that of 1975. Consumption of slab zinc was estimated at 138,000 tons, up slightly over that of 1975.

Texasgulf Inc. mined about 1.55 million tons of ore from the open pit and about 2.05 million tons from underground workings at the Kidd Creek mine in Timmins, Ontario. The program to increase mine capacity to 5 million tons of ore per year by the addition of the No. 2 underground mine and fourth concentrator circuit was on schedule. Work was already in progress to develop the ore between the 2,600- and 2,800-foot levels.[21]

In New Brunswick, Brunswick Mining & Smelting Corp. Ltd. continued its expansion of the No. 12 mine to increase capacity to 11,000 tons per day by 1979. The company experienced a total operating cost per ton of ore milled of $20.06, compared with $15.81 in 1975 at its No. 12 underground mine. The cost was $11.84 at the open pit mine, up from $9.83 in 1975.[22] Texasgulf continued evaluation work at its Half Mile Lake project but deferred sinking an exploration shaft.

On Baffin Island in the Northwest Territories, Nanisivik Mines Ltd., in which Texasgulf has a 35% net profits interest, began production in September at the Nanisivik mine, which has a capacity of 1,500 tons of ore per day. Texasgulf continued drilling at Izok Lake and estimated that the deposit contained 12 million tons of ore assaying 13.8% zinc.

In British Columbia, Northair Mines Ltd. began production in March at its gold-lead-zinc mine near Brandywine Falls. Concentrate from the 300-ton-per-day mill was shipped to Cominco at Trail for smelting. Ore reserves were estimated at 460,000 tons averaging 3.1% zinc and 2.3% lead.

Lemoine Mines Ltd., a wholly owned subsidiary of Patino Mines (Quebec) Ltd., began commercial operation of its mine in early 1976. Mattagami Lake Mines, Ltd., shipped 76% of its zinc concentrate from the Mattagami mine in Quebec to the Valleyfield smelter in Quebec and 24% was exported.[23] Almost 70% of the mill feed came from pillars because the major part of the stoping sections have been mined to the extremities of the ore body. Orchan Mines Ltd. supplemented production from the Orchan main mine with ore from the Norita division. Site preparation was begun for

[20]Brown, D. H. Canadian Mineral Survey 1976. Department of Energy, Mines, and Resources, Ottawa, Canada. February 1977, pp. 30-37.

[21]Texasgulf Inc. 1976 Annual Report. Pp. 12-15.

[22]Brunswick Mining and Smelting Corp. Ltd. 1976 Annual Report. Pp. 6-7.

Where necessary, values have been converted from Canadian dollars (Can$) to U.S. dollars at the rate of CAN$0.986=US$1.00.

[23]Mattagami Lake Mines Ltd. 1976 Annual Report. P. 8.

development of a low-grade zinc-copper deposit acquired from Phelps Dodge of Canada.[24]

In Manitoba, ore production by Hudson Bay Mining & Smelting Co., Ltd., was 92,333 tons more than that of 1975 owing to improved mining methods and initial production from the Centennial mine in the Flin Flon-Snow Lake area. The Schist Lake mine closed due to ore depletion. Development work continued on the Centennial and Westarm mines.[25] Production at the Ruttan and Fox mines of Sherritt Gordon Mines Ltd. decreased owing to operating problems, but the decreases were partially offset by higher metallurgical recoveries. Favorable results from the underground drilling program at Ruttan led to the decision to mine a substantial part of the reserves during 1979-86.[26]

Zinc production in the Yukon was adversely affected by a 169-day strike at the Cyprus Anvil mine, where output fell by about one-half. A 2-month strike cut production 16% at United Keno Hill Mines Ltd.[27] The evaluation of the Grum zinc-lead-silver deposit, in which Kerr Addison held a 60% interest, was completed and feasibility and ecological studies were underway.

Texasgulf Canada Ltd. produced 107,700 tons of zinc metal at its smelter in Ontario, up from 93,000 tons in 1975. Cominco Ltd. produced 224,000 tons at Trail, British Columbia, up from 194,000 tons in 1975. [28] Canadian Electrolytic Zinc completed a 50% expansion of its Valleyfield, Quebec smelter to a capacity of 225,000 tons per year. Production of metal in 1976 was 125,800 tons, compared with 117,700 tons in 1975. Hudson Bay Mining & Smelting Co., Ltd., produced 60,340 tons of zinc.

Canadian zinc reserves on January 1, 1976, were given as 31 million tons at the producing mines and deposits under development, with the Provinces of New Brunswick and Ontario containing about one half of the total.[29]

France.—Société Minière et Métallurgique de Peñarroya began operations at its Noailhac-Saint Salvy mine in January. The capacity of the mill is 1,300 tons per day to produce a concentrate containing 52% zinc and 5% lead. The concentrate is moved by road and rail to Peñarroya's Imperial Smelting furnace at Noyelles-Godault.

Honduras.—Production from the El Mochito mine of Rosario Resources Corp. was 353,907 tons grading 8.38% zinc, 7.26% lead, and 9.68 ounces silver per ton, and containing minor quantities of gold.[30] Zinc in concentrates was 24,063 tons. Reserves decreased 155,000 tons to 1.51 million tons averaging 8.16% zinc and 4.84% lead.

Ireland.—Tara Mines Ltd. completed construction of the mine site surface and ore treatment facilities at its Navan zinc-lead mine, and crushed ore was hoisted to the surface for stockpiling. The mine was expected to provide about 2.5 million tons of ore per year to the 7,500-ton-per-day concentrator during the 25-year lease. About 440,000 tons of zinc concentrates and 80,000 tons of lead concentrates were to be exported to nine European smelters under contracts that provided for diversion of the concentrate to an Irish smelter, should one be built. Ore reserves total about 67 million tons grading 11% zinc and 2.4% lead. [31]

Irish Base Metals, a subsidiary of Northgate Exploration Ltd., treated 594,823 tons of ore from the Tynagh mine, County Galway. The ore grade was 3.02% zinc, compared with 4.27% in 1975. Metallurgical recovery of zinc was 77%, down from 80% in 1975. Direct operating costs per ton of ore mined during 1976 were $12.02, down from $13.78 in 1975. Ore reserves were given at 2.8 million tons assaying 3.89% lead, 3.75% zinc, 0.18% copper, and 0.9 ounce of silver per ton. Sufficient diamond drilling was completed to establish ore reserves over the full extent of Zone III. At the Tatestown zinc-lead prospect in the Navan area, Northgate indicated the possibility of a 1.6-million-ton deposit containing close to 7% combined zinc and lead.[32]

Mogul of Ireland Ltd., of which Kerr Addison bought 75% interest in 1976, mined 1 million tons of ore grading 6.26% zinc and 2.27% lead.[33] Operating costs increased 18% over those of 1975, with energy costs increasing 24%. Metal recovery of zinc was 87%. Ore reserves after dilution were 5 million tons grading 6.05% zinc and 2.57% lead.

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[24] Noranda Mines Ltd. 1976 Annual Report. P. 35.
[25] Hudson Bay Mining & Smelting Co., Ltd. 1976 Annual Report. Pp. 5-6.
[26] Sherritt Gordon Mines Ltd. 1976 Annual Report. Pp. 6-7.
[27] Falconbridge Nickel Mines Ltd. 1976 Annual Report. P. 40.
[28] Cominco Ltd. 1976 Annual Report. P. 8.
[29] Page 20 of work cited in footnote 20.
[30] Rosario Resources Corp. 1976 Annual Report. Pp. 5-6.
[31] Tara Exploration and Development Co. 1976 Annual Report. Pp. 5-8.
[32] Northgate Exploration Ltd. 1976 Annual Report. Pp. 10-11.
[33] Silvermines Ltd. 1976 Annual Report. Pp. 18-19.

Japan.—Japanese zinc metal producers operated at about 75% capacity in 1976, turning out 818,000 tons of metal compared with 773,600 tons in 1975. A stockpile program to stabilize supply and contribute to national security was begun with Government support for several metals including zinc. By October, 13,228 tons of zinc metal had been purchased from domestic refiners. Mitsui Mining & Smelting Co., Ltd., and Sumitomo Metal Mining Co. began toll-refining zinc concentrates from Mt. Isa in Australia for ASARCO. The arrangement utilized excess Japanese capacity and made up for some of the metal loss experienced by ASARCO when it closed its Amarillo, Tex., smelter in 1975.

Korea, Republic of.—A 55,000-ton-per-year electrolytic zinc plant was being constructed at Onsan by Korea Zinc Co., with technical assistance from Toho Zinc Co. of Japan. When completed in late 1977, the plant will use concentrates from the Renka mine and from Toho zinc purchases.

Mexico.—Industrial Minera Mexico, S.A., completed expansion programs at the San Martin and Charcas mines, where capacities were increased 85% and 30%, respectively. The first phase of an expansion plan to increase capacity of the Santa Barbara mine by 25% was almost completed. The expanded Taxco mine became fully operational in 1976. Zinc production of Industrial Minera was 146,700 tons compared with 127,300 tons in 1975.[34]

Nicaragua.—Neptune Mining Co., owned 51.8% by ASARCO, treated 182,632 tons of ore averaging 9.1% zinc and 0.8% lead.[35] Reserves were estimated at 1.16 million tons grading 8.61% zinc, and 1.15% lead, with lesser amounts of copper, silver, and gold.

Peru.—Minero Perú signed a contract with Sybetra of Belgium for the construction of a 110,000-ton-per-year zinc refinery to be built at Cajamarquilla at a cost of $200 million. Centromin, through its Casapalca, Cerro, Morococha, San Cristobal, and Yauricocha mines, was the country's major zinc producer. Work began at the La Oroya zinc plant to increase its capacity to 99,000 tons per year. The Puquio Cocha mine closed after 70 years owing to depletion of its copper-silver-zinc ore. The principal zinc producing mines, in order of quantity produced, were San Ignacio, Sta. Luisa, Huaron, Santander, Atacocha, Milpo, Volcan, Raura, Gran Bretaña, and Madrigal.

Cía. Minerales Santander, Inc., a subsidiary of St. Joe Minerals Corp., produced 44,089 tons of zinc concentrate for export, down from 49,103 tons in 1975.

Cia. Minera del Madrigal, a division of Homestake Mining Co., milled 277,373 tons of copper-lead-zinc ore to produce 19,249 tons of zinc concentrate.[36] The capacity of the plant was being increased from 770 tons to about 1,100 tons per day. Ore reserves totaled 1.2 million tons grading 5% zinc, 2.6% lead, and 1.5% copper. ASARCO, through Northern Peru Mining Corp., produced 6,200 tons of zinc from the Quiruvilca mine.

South Africa, Republic of.—Prieska Copper Mines (Pty.) Ltd., the sole zinc producer, milled 2.4 million tons of ore containing 3.55% zinc to produce 165,261 tons of concentrate containing 52.4% zinc. The company sold its concentrate for domestic consumption to Zinc Corp. of South Africa (ZINCOR), and exported concentrate under contract to Metallgesellschaft. Most of ZINCOR's imported concentrate for its smelter feed came from Canada and Australia.

Phelps Dodge Corp. reported that one of its three ore bodies at Aggeneys in northern Cape Province could be developed as an underground rather than open pit mine. Ore reserves minable by underground methods were estimated at 38 million tons, averaging 6.35% lead, 2.85% zinc, 0.45% copper, and 2.6 ounces of silver per ton.[37]

Newmont Mining Corp. and O'okiep Copper Co. Ltd. continued metallurgical testing and underground work on the Gamsburg zinc deposit in Cape Province. A total of 8,878 tons of ore was tested in the 50-ton-per-day pilot plant. The presence of manganese in the concentrates was successfully controlled in electrolytic refining.[38]

South-West Africa, Territory of.—At the Tsumeb mine, Tsumeb Corp. Ltd. mined and milled 488,796 tons of ore grading 2.39% zinc, 9.04% lead, and 4.25% copper, a slight increase compared with 1975 production. Zinc in concentrates was 2,000 tons. Ore reserves at the mine at yearend were estimated at 5.2 million tons containing 7.43% lead, 4.53% copper, and 1.96% zinc.[39]

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[34]Pages 16 and 18 of work cited in footnote 3.
[35]Page 12 of work cited in footnote 3.
[36]Page 20 of work cited in footnote 4.
[37]Phelps Dodge Corp. 1976 Annual Report. Pp. 8-9.
[38]O'okeip Copper Company Ltd. 1976 Annual Report. P. 4.
[39]Page 14 of work cited in footnote 5.

TECHNOLOGY

Studies on the activation of sphalerite during flotation were pursued at the Bureau of Mines College Park Metallurgy Research Center.[40] The reduction of zinc sulfide concentrates with iron was demonstrated to be technically feasible on a semicontinuous bench-scale operation at the Albany Metallurgy Research Center.[41] Work continued at the Reno Metallurgy Research Center on the fused salt electrolysis of zinc chloride to produce zinc and recycle the chlorine.[42]

AMAX began using a technique for preleaching zinc concentrate from dolomitic limestone ores at its Sauget, Ill., refinery. Preleaching in weak sulfuric acid prevents buildup of magnesium in the electrolyte.[43] A new acid leach process was developed for treating zinc silicate ores so that the silica can be easily separated from the solution.[44] A study was done on the sphalerite content of coals from the Illinois Basin and it was found that the zinc content was as high as 5,350 parts per million and cadmium, as high as 65 parts per million. The sphalerite was readily removed from the coal by washing.[45]

An evaluation was made of the capital requirements to expand U.S. primary metals production capacity, and the factors which influence costs and prices. For zinc the average construction cost per ton of capacity per year was $1,600 for a 50,000-ton-per-year plant; operating costs for mining, milling, and refining were estimated at 19 cents per pound.[46]

A comprehensive coverage of zinc-related investigations and an extensive review of current world literature on the uses of zinc and its products are contained in bimonthly issues of the 1976 Zinc Abstracts published by the Zinc Institute Inc., 292 Madison Avenue, New York, N. Y. 10017, and provided free of charge.

Progress reports of the projects supported by the International Lead Zinc Research Organization, Inc., are released annually in the ILZRO Research Digest.

[40] Maust, E. E. Jr., and P. E. Richardson. Electrophysical Considerations of the Activation of Sphalerite for Flotation. BuMines RI 8108, 1976, 22 pp.

[41] Sanker, P. E., L. L. Oden, and T. T. Campbell. Reduction of Zinc Sulfide With Iron. BuMines RI 8114, 1976, 33 pp.

[42] Haver, F. P., D. E. Shanks, D. L. Bixby, and M. M. Wong. Recovery of Zinc From Zinc Chloride by Fused-Salt Electrolysis. BuMines RI 8133, 1976, 16 pp.

[43] Gorman, J. E., R. F. Pagel, and E. H. Nenninger. Preleaching Zinc Concentrates at AMAX's Sauget Refinery. Eng. and Min. J., v. 177, No. 8, August 1976, pp. 65-69.

[44] Dufresne, R. E. Quick Leach of Siliceous Zinc Ores. J. Metals, v. 28, No. 2, February 1976, pp. 8-12.

[45] Hatch, J. R., H. J. Gluskoter, and P. C. Lindahl. Sphalerite in Coals From the Illinois Basin. Econ. Geol., v. 71, 1976, pp. 613-624.

[46] Boik, B. C. and L. R. Verney. Investment and Operating Costs as a Factor in Metals Availability and Price in the U.S.A. Pres. at Am. Inst. Chem. Eng. Symposium, Atlantic City, N. J., Aug. 31, 1976.

Table 3.—Mine production of recoverable zinc in the United States, by State

(Short tons)

State	1972	1973	1974	1975	1976
Arizona	10,111	8,427	9,699	8,655	9,501
California	1,202	20	8	206	170
Colorado	63,801	58,339	49,489	48,460	50,621
Idaho	38,647	46,107	39,469	40,926	46,586
Illinois	11,378	5,250	4,104	W	W
Kentucky	1,780	273	--	41	59
Maine	5,820	19,640	10,425	8,318	7,810
Missouri	61,923	82,350	91,987	74,867	83,530
Montana	12	73	136	110	64
Nevada	--	--	3,405	5,496	1,438
New Jersey	38,096	33,027	32,848	31,105	33,767
New Mexico	12,735	12,327	13,784	11,015	W
New York	60,749	81,455	93,077	76,612	73,671
Pennsylvania	18,344	18,857	20,288	21,090	22,280
Tennessee	101,722	64,172	85,671	83,293	82,512
Utah	21,853	16,800	12,619	19,640	22,481
Virginia	16,789	16,683	17,195	15,151	11,241
Washington	6,483	6,378	6,909	W	W
Wisconsin	6,873	8,672	8,737	W	W
Other States	--	--	23	24,370	38,782
Total	478,318	478,850	[1]499,872	469,355	484,513

W Withheld to avoid disclosing company confidential data, included with "Other States."

[1] Data do not add to total shown because of independent rounding.

Table 4.—Mine production of recoverable zinc in the United States, by month

(Short tons)

Month	1975	1976	Month	1975	1976
January	42,103	40,404	August	39,141	37,165
February	39,129	41,632	September	37,427	40,499
March	41,562	42,862	October	39,623	40,507
April	40,304	41,199	November	36,355	39,573
May	40,260	41,733	December	37,068	38,794
June	39,492	41,112	Total	469,355	484,513
July	36,891	39,033			

Table 5.—Production of zinc and lead in the United States in 1976, by State and class of ore, from old tailings, etc., in terms of recoverable metals

(Short tons)

State	Zinc ore			Lead ore			Zinc-lead ore		
	Gross weight (dry basis)	Zinc content	Lead content	Gross weight (dry basis)	Zinc content	Lead content	Gross weight (dry basis)	Zinc content	Lead content
Alaska	--	--	--	78	--	14	--	--	--
Arizona	--	--	--	213	1	11	1,100	114	45
California	2,300	164	46	--	--	--	--	--	--
Colorado	178,945	12,908	1,658	206	--	13	521,216	24,761	15,244
Idaho	(1)	(1)	(1)	187,733	2,315	19,461	1,129,543	42,061	33,080
Kentucky	--	--	--	--	--	--	--	--	--
Maine	--	--	--	--	--	--	--	--	--
Missouri	--	--	--	8,657,845	83,530	500,991	--	--	--
Montana	35	1	--	488	5	28	--	--	--
Nevada	8,300	320	33	--	--	--	77,450	1,110	516
New Jersey	207,900	33,767	--	--	--	--	--	--	--
New York	1,239,456	73,671	3,196	--	--	--	--	--	--
Pennsylvania	521,072	22,280	--	--	--	--	--	--	--
Tennessee	3,125,452	78,218	--	--	--	--	--	--	--
Utah	--	--	--	3,621	--	577	366,140	22,481	15,720
Virginia	522,443	11,241	1,946	--	--	--	--	--	--
Other States[2]	581,803	22,164	3,126	150	--	11	380,581	12,793	2,037
Total	6,387,706	254,734	10,005	8,850,334	85,851	521,106	2,476,030	103,320	66,642
Percent of total zinc-lead	--	53	2	--	18	85	--	21	11

See footnotes at end of table.

Table 5.—Production of zinc and lead in the United States in 1976, by State and class of ore, from old tailings, etc., in terms of recoverable metals- Continued

(Short tons)

State	Copper-zinc, copper-lead, and copper-zinc-lead ores			All other sources[3]			Total		
	Gross weight (dry basis)	Zinc content	Lead content	Gross weight (dry basis)	Zinc content	Lead content	Gross weight (dry basis)	Zinc content	Lead content
Alaska	--	--	--	--	--	--	78	--	14
Arizona	90,278	9,350	--	65,269,628	36	282	65,361,219	9,501	338
California	--	--	--	3,774	6	8	6,074	170	54
Colorado	361,250	11,940	7,143	197,860	1,012	2,691	1,259,477	50,621	26,749
Idaho	(1)	(1)	(1)	[1]501,678	[1]2,210	[1]1,095	1,818,954	46,586	53,636
Kentucky	--	--	--	58,794	59	--	58,794	59	--
Maine	176,079	7,810	216	--	--	--	176,079	7,810	216
Missouri	--	--	--	--	--	--	8,657,845	83,530	500,991
Montana	--	--	--	6,380	58	64	6,903	64	92
Nevada	--	--	--	1,717,575	8	33	1,803,325	1,438	582
New Jersey	--	--	--	--	--	--	207,900	33,767	--
New York	--	--	--	--	--	--	1.239,456	73,671	3,196
Pennsylvania	--	--	--	--	--	--	521,072	22,280	--
Tennessee	2,034,015	4,294	--	--	--	--	5,159,467	82,512	--
Utah	--	--	--	120	--	--	369,881	22,481	16,297
Virginia	--	--	--	--	--	--	522,443	11,241	1,946
Other States[2]	130	2	2	2,819,782	3,823	259	3,782,446	38,782	5,435
Total	2,661,752	33,396	7,361	70,575,591	7,212	4,432	90,951,413	484,513	609,546
Percent of total zinc-lead	--	7	1	--	1	1	--	100	100

[1]Zinc ore and ore from "other sources" combined to avoid disclosing individual company confidential data.
[2]Other States includes Illinois, New Mexico, Oklahoma, Washington, and Wisconsin.
[3]Lead and zinc recovered from copper, gold, silver, and fluorspar ores, and from mill tailings and miscellaneous cleanups.

Table 6.—Twenty-five leading zinc-producing mines in the United States in 1976, in order of output

Rank	Mine	County and State	Operator	Source of zinc
1	Balmat	St. Lawrence, N.Y	St. Joe Minerals Corp	Zinc ore.
2	Buick	Iron, Mo	AMAX Lead Co. of Missouri.	Lead ore.
3	Sterling	Sussex, N.J	New Jersey Zinc Co	Zinc ore.
4	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore.
5	Friedensville	Lehigh, Pa	New Jersey Zinc Co	Zinc ore.
6	Elmwood	Smith, Tenn	do	Do.
7	Star Unit	Shoshone, Idaho	The Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
8	Young	Jefferson, Tenn	ASARCO Incorporated	Zinc ore.
9	Leadville	Lake, Colo	do	Lead-zinc ore.
10	Eagle	Eagle, Colo	New Jersey Zinc Co	Zinc ore.
11	New Market	Jefferson, Tenn	ASARCO Incorporated	Do.
12	Immel	Knox, Tenn	do	Lead-zinc ore.
13	Pend Oreille	Pend Oreille, Wash	The Bunker Hill Co	Do.
14	Ontario	Summit, Utah	Park City Ventures	Zinc ore.
15	Ground Hog	Grant, N. Mex	ASARCO Incorporated	Do.
16	Austinville and Ivanhoe.	Wythe, Va	New Jersey Zinc Co	Do.
17	Zinc Mine Works	Jefferson, Tenn	United States Steel Corp.	Do.
18	Burgin	Utah, Utah	Kennecott Copper Corp	Lead-zinc ore.
19	Idarado	Ouray, and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
20	Magmont	Iron, Mo	Cominco American Inc	Lead ore.
21	Bruce	Yavapai, Ariz	Cyprus Bruce Copper and Zinc Co.	Copper-zinc ore.
22	Jefferson City	Jefferson, Tenn	New Jersey Zinc Co	Zinc ore.
23	Brushy Creek	Reynolds, Mo	St. Joe Minerals Corp	Lead ore.
24	Blue Hill	Hancock, Maine	Kerramerican Inc	Zinc ore.
25	Edwards	St. Lawrence, N.Y	St. Joe Minerals Corp	Do.

Table 7.—Primary and redistilled secondary slab zinc produced in the United States[1]

(Short tons)

	1972	1973	1974	1975	1976
Primary:					
From domestic ores	400,969	399,119	346,993	307,959	381,872
From foreign ores	232,211	184,360	208,195	130,092	116,983
Total	633,180	583,479	555,188	438,051	498,855
Redistilled secondary	73,718	83,187	78,535	57,886	63,555
Total (excludes zinc recovered by remelting)	706,898	666,666	633,723	495,937	562,410

[1]Excludes processed GSA zinc.

Table 8.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by method of reduction

(Short tons)

Method of reduction	1972	1973	1974	1975	1976
Electrolytic primary	259,816	211,921	227,430	232,059	257,624
Distilled	373,364	371,558	327,758	205,992	241,231
Redistilled secondary:					
At primary smelters	63,034	67,758	56,342	34,931	37,624
At secondary smelters	10,684	15,429	22,193	22,955	25,931
Total	706,898	666,666	633,723	495,937	562,410

Table 9.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grade

(Short tons)

Grade	1972	1973	1974	1975	1976
Special High	310,074	275,665	277,024	242,128	234,171
High	44,782	25,900	16,912	18,913	31,378
Intermediate	43,353	38,239	22,818	13,104	21,342
Brass Special	76,954	60,034	9,694	5,629	7,514
Prime Western	231,735	266,828	307,275	216,163	268,005
Total	706,898	666,666	633,723	495,937	562,410

Table 10.—Primary slab zinc produced in the United States, by State where smelted

(Short tons)

State	1972	1973	1974	1975	1976
Idaho	101,743	98,321	92,321	92,300	100,694
Illinois	--	26,616	55,527	55,337	68,206
Montana	69,754	--	--	--	--
Oklahoma	114,162	77,819	43,187	35,071	22,402
Pennsylvania	210,860	250,752	240,891	152,280	218,829
Texas	136,661	129,971	123,262	103,063	88,724
Total	633,180	583,479	555,188	438,051	498,855

Table 11.—Annual slab zinc capacity of primary zinc plants in the United States in 1976

Type of plant	Plant location	Slab zinc capacity (short tons)
Electrolytic plants:		
Amax Zinc Co., Inc	Sauget, Ill	84,000
ASARCO Incorporated	Corpus Christi, Tex	[r]108,000
Bunker Hill Co	Kellogg, Idaho	104,000
Horizontal-retort plants: National Zinc Co.[1]	Bartlesville, Okla	56,000
Vertical-retort plants:		
New Jersey Zinc Co	Palmerton, Pa	118,000
St. Joe Minerals Corp	Monaca, Pa	190,000

[r]Revised.
[1]Closed in mid-1976 and replaced by electrolytic plant of equivalent capacity.

Table 12.—Secondary slab zinc plants, by group capacity, in the United States in 1976

Company	Plant location	Slab zinc capacity (short tons)
Arco Die Cast & Metals Inc	Detroit, Mich	48,500 (all plants)
Belmont Smelting & Refining Works	Brooklyn, N.Y	
W. J. Bullock, Inc	Fairfield, Ala	
Gulf Reduction Co	Houston, Tex	
Hugo Neu-Proler Co	Terminal Island, Calif	
Illinois Smelting & Refining Co	Chicago, Ill	
New England Smelting Works Inc	West Springfield, Mass	
Pacific Smelting Co	Torrance, Calif	
Peerless Alloy Inc	Denver, Colo	
Proler International Corp	Houston, Tex	
Prolerized Schiabo Neu Co	Jersey City, N.J	

Table 13.—Stocks and consumption of new and old zinc scrap in the United States in 1976

(Short tons, zinc content)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts	Consumption New scrap	Consumption Old scrap	Consumption Total	Stocks Dec. 31
Smelters and distillers:						
New clippings	54	1,221	953	--	953	322
Old zinc	623	9,133	--	9,299	9,299	457
Remelt zinc	--	3,948	3,270	--	3,270	678
Engravers' plates	230	1,269	--	1,406	1,406	93
Rod and die scrap	1,050	5,594	--	5,262	5,262	1,382
Diecastings	968	28,282	--	28,142	28,142	1,108
Fragmentized diecastings	1,411	15,062	--	15,587	15,587	886
Remelt die-cast slab	1,004	11,449	--	11,966	11,966	487
Skimmings and ashes	r11,797	52,306	48,251	--	48,251	15,852
Sal skimmings	187	822	965	--	965	44
Die-cast skimmings	1,600	5,852	5,961	--	5,961	1,491
Galvanizers' dross	r21,225	55,078	56,614	--	56,614	19,689
Flue dust	r218	6,756	6,549	--	6,549	425
Chemical residues	--	3,025	3,025	--	3,025	--
Other	15	137	148	--	148	4
Total	r40,332	199,934	125,736	71,662	197,398	42,918
Chemical plant, foundries, and other manufacturers:						
New clippings	1	--	1	--	1	--
Old zinc	15	29	--	35	35	9
Rod and die scrap	10	85	--	87	87	8
Diecastings	6	573	--	540	540	39
Skimmings and ashes	r2,546	5,260	4,754	--	4,754	3,052
Sal skimmings	r1,372	4,625	4,995	--	4,995	1,002
Flue dust	128	1,496	1,611	--	1,611	13
Chemical residues	4,824	9,146	11,004	--	11,004	2,966
Total	r8,902	21,214	22,365	662	23,027	7,089
All classes of consumers:						
New clippings	55	1,221	954	--	954	322
Old zinc	638	9,162	--	9,334	9,334	466
Remelt zinc	--	3,948	3,270	--	3,270	678
Engravers' plates	230	1,269	--	1,406	1,406	93
Rod and die scrap	1,060	5,679	--	5,349	5,349	1,390
Diecastings	974	28,855	--	28,682	28,682	1,147
Fragmentized diecastings	1,411	15,062	--	15,587	15,587	886
Remelt die-cast slab	1,004	11,449	--	11,966	11,966	487
Skimmings and ashes	r14,343	57,566	53,005	--	53,005	18,904
Sal skimmings	r1,559	5,447	5,960	--	5,960	1,046
Die-cast skimmings	1,600	5,852	5,961	--	5,961	1,491
Galvanizers' dross	r21,225	55,078	56,614	--	56,614	19,689
Flue dust	r346	8,252	8,160	--	8,160	438
Chemical residues	4,824	12,171	14,029	--	14,029	2,966
Other	15	137	148	--	148	4
Total	r49,284	221,148	148,101	72,324	220,425	50,007

rRevised.

Table 14.—Production of zinc products from zinc-base scrap in the United States

(Short tons)

Products	1972	1973	1974	1975	1976
Redistilled slab zinc	73,718	83,187	78,535	57,886	63,555
Zinc dust	40,569	36,531	29,339	35,479	40,471
Remelt zinc	5,850	1,096	893	127	342
Remelt die-cast slab	13,555	12,595	12,358	4,829	4,639
Zinc-die and diecasting alloys	3,927	4,786	4,393	4,740	7,049
Galvanizing stocks	872	670	872	1,435	2,486
Secondary zinc in chemical products	50,047	56,591	56,275	r32,966	48,981

rRevised.

Table 15.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1975	1976	Form of recovery	1975	1976
New scrap:			As metal:		
Zinc-base	108,813	147,833	By distillation:		
Copper-base	97,476	129,562	Slab zinc[1]	57,886	63,555
Aluminum-base	--	--	Zinc dust	35,479	40,471
Magnesium-base	173	104	By remelting	1,562	2,828
Total	206,462	277,499	Total	94,927	106,854
Old scrap:			In zinc-base alloys	9,569	11,688
Zinc-base	56,605	71,117	In brass and bronze	145,009	204,530
Copper-base	19,686	23,764	In aluminum-base alloys	337	314
Aluminum-base	240	282	In magnesium-base alloys	393	340
Magnesium-base	208	229	In chemical products:		
Total	76,739	95,392	Zinc oxide (lead free)	19,329	26,069
Grand total	283,201	372,891	Zinc sulfate	4,373	8,724
			Zinc chloride	8,898	13,862
			Miscellaneous	366	510
			Total	188,274	266,037
			Grand total	283,201	372,891

[1]Includes zinc content of redistilled slab made from remelt die-cast slab.

Table 16.—Zinc dust produced in the United States

Year	Quantity (short tons)	Value	
		Total (thousands)	Average per pound
1972	59,358	$24,669	$0.208
1973	56,154	29,279	.261
1974	50,775	46,398	.457
1975	r42,149	r40,294	.478
1976	46,358	45,282	.488

rRevised.

Table 17.—Consumption of zinc in the United States

(Short tons)

	1972	1973	1974	1975	1976
Slab zinc	1,418,349	1,503,938	1,287,696	925,330	1,134,141
Ores (zinc content)[1]	118,305	129,651	127,113	82,732	101,241
Secondary (zinc content)[2]	307,369	298,336	258,204	223,753	306,508
Total	1,844,023	1,931,925	1,673,013	1,231,815	1,541,890

[1]Includes ore used directly in galvanizing.
[2]Excludes redistilled slab and remelt zinc.

Table 18.—Slab zinc consumption in the United States, by industry use

(Short tons)

Industry and product	1972	1973	1974	1975	1976
Galvanizing:					
Sheet and strip	294,205	321,927	291,008	185,795	246,744
Wire and wire rope	30,769	34,315	27,579	24,945	26,801
Tubes and pipe	64,549	68,048	59,995	47,180	48,968
Fittings (for tube and pipe)	11,106	11,969	9,294	6,359	6,450
Tanks and containers	3,645	2,941	3,203	1,917	3,326
Structural shapes	20,302	21,714	36,784	41,235	34,568
Fasteners	4,310	4,782	5,703	4,426	4,028
Pole-line hardware	8,437	8,193	6,783	4,934	4,728
Fencing, wire cloth, and netting	21,995	25,418	26,284	20,051	22,006
Other and unspecified uses	58,886	64,530	56,636	40,045	35,464
Total	518,204	563,837	523,269	376,887	433,083
Brass products:					
Sheet, strip, plate	105,405	109,582	99,971	64,958	91,157
Rod and wire	63,143	63,164	57,725	33,415	54,552
Tube	8,886	10,858	9,930	6,451	7,388
Castings and billets	6,840	6,000	4,431	3,079	4,240
Copper-base ingots	7,137	6,895	8,244	6,623	7,681
Other copper-base products	736	1,151	1,262	800	1,226
Total	192,147	197,650	181,563	115,326	166,244
Zinc-base alloy:					
Diecasting alloy	566,932	598,725	436,377	330,190	419,708
Dies and rod alloy	56	111	384	149	1,028
Slush and sand casting alloy	12,773	11,770	3,498	3,852	6,295
Total	579,761	610,606	440,259	334,191	427,031
Rolled zinc	45,216	40,763	39,393	27,308	29,859
Zinc oxide	51,992	61,734	65,376	39,020	39,027
Other uses:					
Light-metal alloys	6,300	7,466	9,690	5,832	5,767
Other [1]	24,729	21,882	28,146	26,766	33,130
Total	31,029	29,348	37,836	32,598	38,897
Grand total	1,418,349	1,503,938	1,287,696	925,330	1,134,141

[1]Includes zinc used in making zinc dust, wet batteries, desilverizing lead, powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.

Table 19.—Slab zinc consumption in the United States in 1976, by grade and industry use

(Short tons)

Industry	Special High Grade	High Grade	Intermediate	Brass Special	Prime[1] Western	Remelt	Total
Galvanizing	25,601	18,693	11,088	102,344	274,505	852	433,083
Brass and bronze	51,206	85,335	21	2,086	27,403	193	166,244
Zinc-base alloys	424,915	1,598	--	--	301	217	427,031
Rolled zinc	17,698	66	12,095	--	--	--	29,859
Zinc oxide	17,675	--	--	--	21,352	--	39,027
Other	14,175	5,715	--	30	18,977	--	38,897
Total	551,270	111,407	23,204	104,460	342,538	1,262	1,134,141

[1]Includes select grade.

Table 20.—Rolled zinc produced and quantity available for consumption in the United States

	1975			1976		
		Value			Value	
	Short tons	Total (thousands)	Average per pound	Short tons	Total (thousands)	Average per pound
Production:[1]						
Photoengraving plate	2,898	$3,467	$0.598	W	W	W
Strip and foil	21,010	r22,762	r.542	22,259	$24,498	$0.550
Total rolled zinc[2]	r26,450	r31,217	r.589	29,874	33,482	.560
Exports	1,629	2,086	.640	2,271	2,817	.620
Imports	236	507	1.074	209	392	.938
Available for consumption	r24,383	--	--	29,058	--	--

rRevised. W Withheld to avoid disclosing individual company confidential data, included in total.
[1]Figures represent net production. In addition, 22,153 tons in 1975 and 24,630 tons in 1976 were rerolled from scrap originating in fabricating plants operating in connection with zinc-rolling mills.
[2]Includes other plate over 0.375 inch thick, sheet zinc less than 0.375 inch thick, and rod and wire. Bureau of Mines not at liberty to publish separately.

Table 21.—Slab zinc consumption in the United States in 1976, by industry and State

(Short tons)

State	Galvanizers	Brass mills[1]	Die casters[2]	Other[3]	Total
Alabama	31,601	W	--	W	34,096
Arizona	--	--	--	W	W
Arkansas	W	--	--	W	4,619
California	32,642	3,282	W	W	48,162
Colorado	--	--	W	W	1,638
Connecticut	3,072	25,593	W	W	34,289
Delaware	W	W	--	W	W
Florida	4,465	--	--	--	4,465
Georgia	W	--	W	--	W
Hawaii	W	--	--	--	W
Idaho	--	--	W	W	W
Illinois	54,873	25,732	69,292	5,460	155,357
Indiana	51,630	W	W	W	117,070
Iowa	540	--	W	W	1,909
Kansas	--	W	W	W	W
Kentucky	W	W	--	W	W
Louisiana	3,369	--	W	W	4,997
Maine	W	--	--	--	W
Maryland	W	--	--	W	18,450
Massachusetts	2,969	W	W	W	5,646
Michigan	W	19,484	90,676	W	113,882
Minnesota	900	--	--	--	900
Mississippi	1,924	--	--	--	1,924
Missouri	7,584	W	W	W	11,852
Nebraska	7,168	W	--	W	7,730
New Jersey	2,709	4,636	W	W	13,719
New York	12,517	W	85,992	W	119,542
North Carolina	W	--	W	--	W
Ohio	68,298	W	73,713	W	152,814
Oklahoma	W	--	--	W	4,714
Oregon	1,043	W	W	W	1,608
Pennsylvania	55,092	7,898	W	W	124,991
Rhode Island	W	W	--	W	W
South Carolina	W	--	--	--	W
Tennessee	W	--	W	W	W
Texas	15,827	W	W	1,816	48,420
Utah	W	W	--	--	W
Virginia	W	W	W	264	922
Washington	W	--	--	W	1,920
West Virginia	W	--	--	W	22,366
Wisconsin	856	W	7,307	W	13,873
Undistributed	73,152	79,426	99,834	100,243	61,004
Total[4]	432,231	166,051	426,814	107,783	1,132,879

W Withheld to avoid disclosing individual company confidential data; included with 'Undistributed.'
[1]Includes brass mills, brass ingot makers, and brass foundries.
[2]Includes producers of zinc-base alloy for diecastings, stamping dies, and rods.
[3]Includes slab zinc used in rolled zinc products and in zinc oxide.
[4]Excludes remelt zinc.

Table 22.—Production and shipments of zinc pigments and compounds[1] in the United States

Pigment or compound	1975 Production (short tons)	1975 Shipments Quantity (short tons)	1975 Shipments Value[2] Total (thousands)	1975 Shipments Value[2] Average per ton	1976 Production (short tons)	1976 Shipments Quantity (short tons)	1976 Shipments Value[2] Total (thousands)	1976 Shipments Value[2] Average per ton
Zinc oxide[3]	165,400	169,485	$122,158	$721	194,481	198,078	$136,447	$689
Zinc sulfate	23,394	23,492	5,800	247	34,681	34,344	10,096	294
Zinc chloride, 50°B[4]	W	W	W	W	32,626	25,184	W	W

W Withheld to avoid disclosing individual company confidential data.
[1]Excludes leaded zinc oxide and lithopone.
[2]Value at plant, exclusive of container.
[3]Zinc oxide containing 5% or more lead is classed as leaded zinc oxide.
[4]Includes zinc content of zinc ammonium chloride and chromated zinc chloride.

Table 23.—Zinc content of zinc pigments[1] and compounds produced by domestic manufacturers, by source

(Short tons)

Pigment or compound	1975 Zinc in pigments and compounds produced from— Ore	1975 Slab zinc	1975 Secondary material	1975 Total zinc in pigments and compounds	1976 Zinc in pigments and compounds produced from— Ore	1976 Slab zinc	1976 Secondary material	1976 Total zinc in pigments and compounds
Zinc oxide	74,148	38,853	19,329	132,330	91,399	38,166	26,069	155,634
Zinc sulfate	1,739	--	4,373	r6,112	1,736	--	11,861	13,597
Zinc chloride[2]	--	--	W	W	--	--	10,634	10,634

rRevised. W Withheld to avoid disclosing individual company confidential data.
[1]Excludes leaded zinc oxide, zinc sulfide, and lithopone.
[2]Includes zinc content of zinc ammonium chloride and chromated zinc chloride.

Table 24.—Distribution of zinc oxide shipments, by industry

(Short tons)

Industry	1972	1973	1974	1975	1976
Rubber	129,170	129,462	108,976	96,209	104,669
Paints	27,244	26,115	17,029	11,016	15,699
Ceramics	10,702	11,678	12,177	6,300	8,433
Chemicals	22,781	26,187	35,167	17,544	33,186
Agriculture	1,101	2,044	6,066	1,847	3,481
Photocopying	36,190	38,724	34,577	24,647	24,149
Other	18,679	18,623	18,550	11,922	8,461
Total	245,867	252,833	232,542	169,485	198,078

Table 25.—Distribution of zinc sulfate shipments, by industry

(Short tons)

Year	Agriculture Gross weight	Agriculture Dry basis	Other[1] Gross weight	Other[1] Dry basis	Total Gross weight	Total Dry basis
1972	10,496	8,602	29,099	25,935	39,595	34,537
1973	13,909	8,353	31,288	24,902	45,197	33,255
1974	14,508	8,677	29,627	18,245	44,135	26,922
1975	8,470	3,579	15,022	5,852	23,492	9,431
1976	12,797	5,326	21,547	10,283	34,344	15,609

[1]Includes rayon; Bureau of Mines not at liberty to publish separately.

Table 26.—Stocks of slab zinc at zinc-reduction plants in the United States, December 31

(Short tons)

	1972	1973	1974	1975	1976
At primary reduction plants	28,843	25,229	38,293	r73,431	92,553
At secondary distilling plants	1,225	718	1,427	1,245	1,340
Total	30,068	25,947	39,720	r74,676	93,893

rRevised.

Table 27.—Consumer stocks of slab zinc at plants, December 31, by grade

(Short tons)

Year	Special High Grade	High Grade	Intermediate	Brass Special	Prime Western	Remelt	Total
1975	39,139	8,155	3,728	7,227	48,826	201	107,276
1976	44,479	10,870	3,467	8,419	53,739	180	121,154

Table 28.—Average monthly U.S., LME,[1] and European Producers' prices for Prime Western zinc and equivalent

(Metallic zinc, cents per pound)

Month	1975			1976		
	United States	LME cash	European producer	United States	LME cash	European producer
January	39.15	36.18	38.58	37.12	31.34	36.05
February	39.11	35.97	39.12	37.00	31.27	36.05
March	38.95	36.41	39.49	37.00	32.92	36.05
April	38.93	35.46	38.71	37.00	35.78	36.05
May	38.94	33.84	37.89	37.00	35.03	36.05
June	38.94	34.01	37.24	37.00	35.93	36.05
July	38.92	32.05	35.67	37.00	35.12	36.05
August	38.90	33.39	34.53	37.00	33.53	36.05
September	38.89	32.80	34.02	37.00	32.27	36.05
October	38.96	31.98	34.86	37.00	28.94	36.05
November	38.90	31.95	36.24	37.00	27.34	36.05
December	38.93	31.08	35.77	37.00	29.07	36.05
Average for year	38.96	33.76	36.84	37.01	32.38	36.05

[1]London Metal Exchange.

Source: Metals Week.

Table 29.—U.S. exports of zinc and zinc alloys, by country

Destination	1974 Quantity (short tons)	1974 Value (thousands)	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Unwrought zinc and zinc alloys:						
Argentina	--	--	10	$8	--	--
Belgium-Luxembourg	4,370	$3,578	1	2	11	$13
Brazil	9,094	9,474	1,714	1,628	--	--
Cambodia	72	72	--	--	--	--
Canada	1,333	948	619	528	972	640
Chile	988	1,511	10	22	36	42
Colombia	1,385	1,083	142	127	12	22
Costa Rica	678	735	6	9	2	3
Dominican Republic	293	207	55	37	1	2
El Salvador	456	347	1	4	--	--
France	810	278	397	339	216	105
Germany, West	104	81	64	31	36	29
Greece	373	515	4	7	--	--
Guatemala	674	831	26	21	(1)	1
Israel	226	331	--	--	6	12
Italy	534	978	--	--	17	13
Japan	2,385	2,498	479	391	5	15
Korea, Republic of	1,301	1,385	118	50	59	29
Malaysia	11	16	--	--	--	--
Mexico	144	158	181	108	163	85
Netherlands	3,399	2,547	4,107	3,781	2,873	1,918
Nicaragua	226	249	2	2	71	57
Pakistan	107	70	--	--	--	--
Panama	282	300	2	11	5	7
Philippines	1,925	1,926	5	8	6	9
Saudi Arabia	--	--	--	--	351	435
Singapore	491	530	38	57	19	30
South Africa, Republic of	100	37	--	--	23	28
Spain	60	34	58	47	--	--
Switzerland	12	5	--	--	--	--
Taiwan	185	173	4	10	1	4
Thailand	227	247	--	--	--	--
United Arab Emirates	6	9	21	39	34	44
United Kingdom	1,965	1,381	202	194	(1)	4
Venezuela	2,947	3,256	1,319	1,094	164	143
Vietnam, South	441	399	--	--	--	--
Other	323	421	42	87	23	39
Total	37,927	36,610	9,627	8,642	5,106	3,729
Wrought zinc and zinc alloys:						
Algeria	3	5	24	53	31	56
Australia	70	113	53	91	98	182
Belgium-Luxembourg	5,143	3,220	8,159	4,113	4,825	2,541
Brazil	299	140	133	103	--	--
Canada	3,659	2,797	3,137	1,975	3,344	2,369
Chile	56	67	49	65	17	23
Colombia	58	79	58	73	69	88
Denmark	--	--	9	11	23	36
Dominican Republic	15	22	112	121	13	27
Ecuador	45	62	26	38	29	52
Egypt	9	10	56	79	23	28
France	59	77	1	1	3	1
Germany, West	30	193	63	57	10	73
Hong Kong	204	212	81	93	115	130
Indonesia	150	224	1	5	--	--
Israel	55	65	48	56	60	78
Japan	44	47	2	4	5	24
Lebanon	34	30	33	43	--	--
Mexico	277	209	81	84	59	112
Netherlands	572	723	10	76	14	37
New Zealand	85	91	41	47	107	122
Panama	30	46	17	5	58	115
Peru	16	23	124	312	28	45
Philippines	351	169	40	53	57	76
Saudi Arabia	25	26	20	4	35	36
Singapore	40	51	5	12	14	16
South Africa, Republic of	271	369	131	191	78	115
Spain	201	257	--	--	11	27
Switzerland	1	1	56	40	48	27
Syria	40	39	8	10	199	76
Taiwan	61	82	13	15	46	52
Thailand	33	24	11	26	31	45
Turkey	--	--	5	6	38	44
United Arab Emirates	167	337	11	19	5	7
United Kingdom	340	275	180	255	189	317
Venezuela	272	407	76	105	69	100
Other	363	594	221	452	247	393
Total	13,078	11,086	13,095	8,693	9,998	7,470

[1]Less than 1/2 unit.

Table 30.—U.S. exports of zinc, by class

Year	Blocks, pigs, anodes, etc.				Wrought zinc and zinc alloys				Waste and scrap (zinc content)		Dust (blue powder)	
	Unwrought		Unwrought alloys		Sheets, plates, and strip		Angles, bars, pipes, rods, etc.					
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	19,062	$16,511	18,865	$20,099	3,487	$3,842	9,591	$7,244	10,936	$5,461	1,152	$819
1975	6,897	5,870	2,730	2,772	1,629	2,086	11,466	6,607	4,448	1,610	603	838
1976	3,513	2,306	1,593	1,423	2,271	2,817	7,727	4,653	8,171	2,820	774	715

Table 31.—U.S. exports of zinc pigments

Kind	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Zinc oxide	3,104	$2,363	4,838	$3,112
Lithopone	917	1,060	779	937
Total	4,021	3,423	5,617	4,049

Table 32.—U.S. exports of lead and zinc ores and concentrates

(Gross weight)

Year	Quantity (short tons)	Value (thousands)
1965	434	$152
1966	49	9
1967	39	16
1968	11,831	2,931
1969	115	47
1970	15,575	1,458
1971	29,145	3,286
1972	43,845	5,802
1973	104,180	18,884
1974	111,176	27,281
1975	150,830	31,502
1976	148,787	28,892

Table 33.—U.S. exports of lead and zinc ores and concentrates, by country

(Gross weight)

Destination	1974 Quantity (short tons)	1974 Value (thousands)	1975 Quantity (short tons	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Argentina	--	--	5,276	$727	--	--
Belgium-Luxembourg	29,268	$7,476	50,666	10,086	62,111	$13,660
Brazil	10,678	2,730	5,690	1,008	16,919	3,487
Bulgaria	--	--	--	--	10,067	1,764
Canada	414	123	5,522	1,559	942	195
Finland	--	--	--	--	5,430	1,500
Germany, West	--	--	6,879	1,646	25,154	3,563
Japan	52,546	11,617	6,271	1,261	15,600	2,526
Mexico	4,563	1,257	8,219	802	11	6
Netherlands	--	--	8,196	2,045	5,907	838
Poland	--	--	19,930	4,614	--	--
Romania	5,588	2,027	--	--	--	--
Spain	--	--	16,282	3,750	5,543	1,070
U.S.S.R	--	--	6,017	1,336	--	--
Yugoslavia	4,985	1,344	10,406	2,286	--	--
Other	3,134	707	1,476	382	1,103	283
Total	111,176	27,281	150,830	31,502	148,787	28,892

Table 34.—U.S. general imports of zinc, by country

Country	1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Australia	5,606	$652	4,044	$485	2,291	$275
Bolivia	1	1	1,217	218	785	87
Canada	162,482	51,104	98,700	37,084	69,901	27,339
Colombia	1	1	8	1	14	2
Germany, West	--	--	20	7	231	103
Greenland	--	--	304	46	530	80
Honduras	6,232	3,184	13,362	4,936	16,307	7,289
Ireland	1,075	160	--	--	--	--
Mexico	24,183	7,509	9,334	3,789	2,625	763
Nicaragua	10,639	4,176	7,299	2,577	3,637	1,982
Peru	13,860	4,341	4,902	2,011	794	166
Thailand	13,317	1,992	5,797	882	--	--
Turkey	2,647	911	--	--	--	--
Total	240,043	74,031	144,987	52,036	97,115	38,086
BLOCKS, PIGS, OR SLABS						
Algeria	--	--	--	--	999	621
Angola	1,922	1,289	5,512	4,354	--	--
Australia	38,909	29,903	22,875	17,295	32,586	23,549
Belgium-Luxembourg	30,379	31,253	19,084	16,456	35,473	23,420
Canada	270,156	182,714	181,692	134,010	313,006	223,125
China, People's Republic of	--	--	298	194	2,532	1,597
Finland	10,590	6,998	19,157	14,264	31,526	23,006
France	4,477	5,271	1,837	1,232	10,397	7,438
Germany, West	8,289	8,008	17,827	12,507	48,665	32,989
Hong Kong	110	109	--	--	--	--
Italy	7,911	9,683	7,299	5,137	30,739	18,867
Japan	52,674	57,651	7,202	5,724	9,483	6,789
Korea, Republic of	--	--	--	--	57	35
Liberia	2,731	2,008	3,601	2,502	--	--
Malaysia	--	--	45	660	--	--
Mexico	23,515	21,750	17,605	12,818	62,638	42,762
Mozambique	558	364	--	--	--	--
Netherlands	5,228	5,708	15,123	10,208	9,642	6,586
Norway	149	112	--	--	1,102	827
Peru	31,101	24,807	19,128	12,917	19,911	13,111
Poland	9,253	10,311	440	292	1,018	619
Singapore	229	204	--	--	--	--
South Africa, Republic of	774	615	2,077	1,698	3,650	2,453
Spain	5,059	4,832	26,268	16,143	29,687	19,892
Switzerland	--	--	--	--	118	89
U.S.S.R	221	261	--	--	--	--
United Kingdom	5,117	4,677	2,200	1,528	1,820	1,190
Yugoslavia	12,348	14,770	7,009	4,557	29,869	19,699
Zaire	17,838	11,772	4,158	2,841	36,922	26,839
Zambia	--	--	--	--	2,649	1,627
Total	539,538	435,070	380,437	277,337	714,489	497,130

Table 35.—U.S. imports for consumption of zinc, by country

Country	1974 Quantity (short tons)	1974 Value (thousands)	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Argentina	6	$1	--	--	--	--
Australia	4,134	$522	22,954	$1,949	2,467	$295
Bolivia	1	[1]	1,217	218	785	87
Canada	73,635	18,678	209,150	57,888	124,320	40,148
Colombia	--	--	8	1	14	2
Germany, West	--	--	20	7	231	103
Greenland	--	--	--	--	721	108
Honduras	18,033	3,793	43,224	13,040	13,069	6,171
Ireland	883	152	4,820	750	--	--
Japan	5	1	--	--	--	--
Mexico	26,647	6,480	61,656	16,037	9,689	1,795
Nicaragua	1,489	236	36,749	8,858	3,019	1,376
Peru	8,900	1,567	20,633	3,991	1,488	468
Thailand	--	--	25,143	5,172	--	--
Turkey	--	--	2,970	911	--	--
Total	133,733	31,430	428,544	108,822	155,803	50,553
BLOCKS, PIGS, OR SLABS						
Algeria	--	--	--	--	999	621
Angola	1,922	1,289	--	--	--	--
Australia	38,909	29,903	22,875	17,295	32,586	23,549
Belgium-Luxembourg	30,379	31,253	17,430	14,417	35,197	23,211
Canada	278,075	184,095	181,725	134,015	313,006	223,125
China, Peoples Republic of	--	--	298	194	2,532	1,597
Finland	10,590	6,998	19,157	14,264	31,526	23,006
France	4,477	5,271	1,837	1,232	8,552	6,099
Germany, West	8,177	7,890	17,853	12,538	47,397	32,119
Hong Kong	110	109	--	--	--	--
Italy	7,635	9,404	5,792	4,202	28,636	19,069
Japan	50,827	55,919	8,403	6,832	--	--
Korea, Republic of	--	--	--	--	57	35
Liberia	2,731	2,008	3,601	2,502	--	--
Malaysia	--	--	45	660	--	--
Mexico	25,675	21,982	14,187	10,083	58,001	39,421
Mozambique	558	364	--	--	--	--
Netherlands	4,895	5,279	15,123	10,208	7,768	5,361
Norway	149	112	--	--	1,102	827
Peru	31,101	24,807	19,128	12,917	19,911	13,111
Poland	8,922	9,968	661	496	1,018	619
Portugal	--	--	104	87	--	--
Romania	--	--	--	--	6,748	1,957
Singapore	229	204	--	--	--	--
South Africa, Republic of	774	615	2,077	1,698	3,650	2,453
Spain	2,413	2,540	28,509	18,895	29,687	19,892
Switzerland	--	--	--	--	118	89
U.S.S.R	221	261	--	--	--	--
United Kingdom	5,447	4,938	2,200	1,528	1,820	1,190
Yugoslavia	11,752	14,269	7,390	4,861	29,869	19,699
Zaire	17,838	11,772	6,527	4,712	32,302	23,588
Zambia	--	--	--	--	2,649	1,627
Total	543,806	431,250	374,922	273,636	695,131	482,265

[1] Less than 1/2 unit.

Table 36.—U.S. imports for consumption of zinc, by class

	Ore (zinc content)		Blocks, pigs, slabs[1]		Sheets, plates, strips other forms		Waste and scrap	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	133,733	$31,430	543,806	$431,250	640	$568	2,418	$1,241
1975	428,544	108,822	374,922	273,636	236	507	1,418	468
1976	155,803	50,553	695,131	482,265	209	329	1,803	516
	Dross and skimmings (zinc content)		**Zinc fume (zinc content)**		**Dust, powder, flakes**		**Total value[2] (thousands)**	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)		
1974	3,863	$1,786	18,235	$3,283	9,131	$9,799	$479,357	
1975	3,158	1,238	33,327	9,442	5,739	5,744	399,857	
1976	12,445	4,884	6,927	2,558	6,009	5,134	546,239	

[1]Unwrought alloys of zinc were imported as follows: 1974, 11,491 short tons ($11,397,967); 1975, 101 short tons ($87,395); 1976, 27 short tons ($14,141).

[2]In addition, manufactures of zinc were imported as follows: 1974, $562,521; 1975, $78,837; 1976, $96,945.

Table 37.—U.S. imports for consumption of zinc pigments and compounds

Kind	1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Zinc oxide	13,187	$8,162	19,913	$12,391
Zinc sulfide	328	214	539	358
Lithopone	15	6	69	25
Zinc chloride	767	518	1,372	701
Zinc sulfate	3,191	1,065	5,435	1,602
Zinc cyanide	10	15	57	84
Zinc compounds, n.s.p.f.	949	766	584	575
Total	18,447	10,746	27,969	15,736

Table 38.—Zinc: World mine production (content of ore), by country

(Short tons)

Country[1]	1974	1975	1976[p]
North America:			
Canada[2]	[r]1,367,077	1,347,574	[e]1,312,500
Guatemala (exports)	--	--	1,624
Honduras	26,411	33,398	27,392
Mexico (recoverable)	289,594	318,403	285,700
Nicaragua	16,334	12,321	15,749
United States (recoverable)	499,872	469,355	484,513
South America:			
Argentina	[r]43,703	41,172	44,600
Bolivia	[r] [3]53,154	[3]51,934	53,513
Brazil	42,255	55,120	67,510
Chile	3,692	3,499	5,573
Colombia	41	8	66
Ecuador	223	91	150
Peru	[r]416,705	424,169	436,240
Europe:			
Austria (recoverable)	23,123	25,397	24,968
Bulgaria[e]	88,000	[r]88,000	93,000
Czechoslovakia	10,296	9,838	13,000
Finland	[r]67,214	59,917	67,399
France	[r]16,075	15,300	34,900
Germany, West	[r]128,554	127,947	126,986
Greece	[r]27,546	15,344	32,012
Greenland	116,051	100,156	[e]98,700
Hungary[e]	[r]3,000	[r]2,400	2,600
Ireland[e]	73,100	73,500	69,200
Italy	[r]85,800	83,792	88,986
Norway	[r]24,291	26,460	32,616
Poland[e]	220,000	[r]230,000	238,000
Romania (recoverable)[e]	66,000	66,000	66,000
Spain	[r]104,454	94,024	93,233
Sweden	125,332	122,715	140,126
U.S.S.R. (recoverable)[e]	750,000	760,000	790,000
United Kingdom	[r]3,316	4,410	3,300
Yugoslavia	104,369	114,023	117,462
Africa:			
Algeria	[r]12,100	16,000	15,400
Congo	3,600	4,400	4,000
Morocco	[r]17,941	23,100	18,904
South Africa, Republic of	[r]37,500	73,014	86,596
South West Africa, Territory of[4]	[r]42,396	36,506	[e]35,800
Tunisia	[r]6,878	7,800	8,000
Zaire	93,106	87,400	77,500
Zambia (recoverable)	[r]64,300	51,600	40,900
Asia:			
Burma	[r]3,308	2,918	2,437
China, People's Republic of, (recoverable)[e]	110,000	110,000	110,000
India	[r]21,227	25,175	28,175
Iran[5]	90,900	72,800	72,800
Japan (recoverable)	265,423	280,453	286,549
Korea, North (recoverable)[e]	179,000	[r]176,000	185,000
Korea, Republic of	44,901	50,617	65,186
Philippines	8,567	11,522	12,577
Thailand[6]	[r]36,240	3,549	18
Turkey	[r]34,800	29,300	33,000
Oceania:Australia	[r]503,821	552,088	511,795
Total	[r]6,371,590	6,390,509	6,462,255

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, Vietnam also produces zinc, but information is inadequate to make reliable estimates.

[2]Zinc content of concentrates.

[3]Production by COMIBOL plus exports by medium, small, and other mines.

[4]Data are compiled from operating company reports of Tsumeb Corp. Ltd. and South African Iron and Steel Industrial Corp., Ltd. (ISCOR), for Imcor Zinc (Pty.) Ltd.'s Rosh Pinah mine. Data from Tsumeb Corp. Ltd. are for calendar years; data from other companies are for fiscal years ending June 30 of the year stated.

[5]Year beginning March 21 of that stated.

[6]Contained in zinc concentrates. Additional quantities of zinc may be contained as a byproduct in lead concentrates produced, but information is inadequate to make reliable estimates of such production, if any.

Table 39.—World smelter production of zinc, by country[1]

(Short tons)

Country[2]	1974	1975	1976[p]
North America:			
Canada	[r]469,884	470,622	521,200
Mexico	[r]150,892	169,711	188,871
United States	555,188	438,051	498,855
South America:			
Argentina	[r]44,100	43,700	44,100
Brazil	33,641	34,643	33,100
Peru	[r]78,681	69,709	71,297
Europe:			
Austria[3]	18,133	17,938	18,270
Belgium	[r]318,347	240,524	258,712
Bulgaria[4]	[r]99,200	101,000	[e]101,400
Finland[4]	101,177	121,127	121,952
France	[r]304,975	199,667	257,118
Germany, East[e] [3]	20,000	20,000	20,000
Germany, West	[r]440,978	324,878	335,933
Italy	[r]216,537	198,120	210,785
Netherlands	[r]86,166	136,623	138,300
Norway	79,845	67,121	69,283
Poland[3]	257,000	268,000	265,000
Romania[e] [3]	77,000	[r]77,000	79,000
Spain	143,307	148,900	177,600
U.S.S.R.[e]	750,000	760,000	790,000
United Kingdom	[r]92,981	58,900	45,900
Yugoslavia[3]	95,218	107,900	116,285
Africa:			
Algeria	9,000	22,000	26,500
South Africa, Republic of	72,100	70,243	73,082
Zaire	[r]72,953	72,298	67,994
Zambia	64,307	51,600	40,900
Asia:			
China, People's Republic of[e]	110,000	110,000	110,000
India[4]	[r]23,264	28,359	29,525
Japan	936,850	773,595	817,990
Korea, North[e]	143,000	[r]154,000	152,000
Korea, Republic of	12,729	23,063	30,007
Thailand[4]	73	73	[e]65
Oceania: Australia	305,154	213,088	267,460
Total	[r]6,182,680	5,592,453	5,978,484

[e]Estimate. [p]Preliminary. [r]Revised.

[1]An attempt has been made to restrict the contents of this table to primary production only. Where secondary metal is inseparably included it has been so noted.

[2]In addition to the countries listed, Vietnam also produces zinc, but information is inadequate to make reliable estimates.

[3]Known to include secondary production recovered from reclaimed scrap.

[4]May include secondary production recovered from reclaimed scrap.

Zirconium and Hafnium

By Sarkis G. Ampian[1]

Zircon production and sales by domestic mining companies decreased nearly 7% in tonnage and more than 20% in value in 1976. Zircon exports decreased 50% from 18,766 tons in 1975 to 9,428 tons in 1976, but imports increased 61% from 40,205 short tons in 1975 to 64,643 short tons in 1976. Total exports of zirconium metal and zirconium alloys generally decreased in 1976, while zirconium oxide increased substantially. Production of zirconium-bearing compounds for chemicals and refractories also decreased slightly. Zircon consumption by foundries increased from 46,200 tons in 1975 to 67,000 tons in 1976. Some hafnium was also produced.

The 1976 worldwide zircon supply-demand picture was characterized by a growing demand owing to increased industrial activity and Australian production capacity, resulting in an oversupply, which depressed prices. Domestically, zircon reflected the worldwide situation, with continued strong demand, largely in manufacturing specialized refractories and abrasives, and the return of foundries to the depressed priced zircon. This increased demand was largely met by imports.

Recycling of spent foundry zircon and substitution of chromite and aluminum silicate-minerals for some zircon foundry applications were commonplace.

Zircon was principally used in foundry sands, refractories, abrasives, ceramics, and as a source of zirconium metal. The metal was used mostly in nuclear reactors, in corrosion resistant equipment for industrial plants, and in refractory alloys. Hafnium was used in nuclear reactors, in flashbulbs, and in refractory alloys.

Legislation and Government Programs.—The Statistical Supplement to the Stockpile Report to Congress, Dec. 31, 1976, showed no objectives for zirconium and hafnium materials. The Energy Research and Development Administration (ERDA) had an inventory, as of June 30, 1976, of approximately one-half ton of zirconium crystal bar and scrap, 937 tons of zirconium sponge, 163 tons of Zircaloy ingot and shapes, one-half ton of hafnium scrap, 5 tons of hafnium oxide, one-half ton of hafnium sponge and shapes, and 39 tons of hafnium crystal bar.

[1]Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient zirconium statistics in the United States

(Short tons)

Product	1972	1973	1974	1975	1976
Zircon					
Production	W	W	W	W	W
Exports	17,360	28,921	21,487	18,766	9,428
Imports	67,537	98,023	62,504	40,205	64,643
Consumption[e 1]	168,000	175,000	167,000	122,000	155,000
Stocks, yearend, dealers' and consumers'[2]	44,500	51,500	41,900	37,033	37,784
Zirconium oxide:					
Production[3]	12,020	14,300	11,630	11,760	8,000
Producers' stocks, yearend[3]	942	648	1,480	1,745	663

[e]Estimate. W Withheld to avoid disclosing individual company confidential data.
[1]Includes baddeleyite: 1972-385 tons; 1973-1,019 tons; 1974-[e]2,950 tons; 1975-[e]1,000; 1976-[e]2,000.
[2]Excludes foundries.
[3]Excludes oxide produced by zirconium metal producers.

DOMESTIC PRODUCTION

E. I. du Pont de Nemours & Co. and Titanium Enterprises, Inc., were the only major producers of zircon mineral concentrate in the United States. Zircon was recovered from mineral sands at the dredging and milling facilities owned by Du Pont at Starke, Fla.; by Humphreys Mining Co. for Du Pont, near Folkston, Ga.; and Titanium Enterprises at Green Cove Springs, Fla. Production data were withheld from publication to avoid disclosing individual company confidential information. The combined zircon capacity of these three plants is estimated to be 135,000 tons per year.

Domestic producers were examining several beach sand ore bodies in the southeastern States and studying the practicality of adding zircon flour to their product lines. NL Industries, Inc., continued feasibility studies on recovering heavy minerals from The Trail Ridge extension in Florida. A decision on the project was expected by midyear 1977.

Statistical data on production of zirconium sponge, ingot, and scrap and on hafnium sponge and oxide are also withheld to avoid disclosure of company confidential data.

Table 2.—Producers of zirconium and hafnium materials in 1976

Company	Location	Materials
ZIRCONIUM MATERIALS		
AMAX Specialty Metals Corp	Akron, N. Y	Ingot, sponge.
Do	Parkersburg, W. Va	Sponge, metal, chloride, oxide.
Babcock & Wilcox Co., Nuclear Materials Div	Parks Township, Pa	Powder, alloys.
Barker Foundry Supply Co	Los Angeles, Calif	Milled zircon.
The Carborundum Co	Falconer, N. Y	Refractories.
C. E. Refractories, Div. of Combustion Engineering, Inc.	St. Louis, Mo	Do.
Do	King of Prussia, Pa	Refractories, zircon.
Do	Vandalia, Mo	Do.
Continental Mineral Processing Corp	Sharonville, Ohio	Milled zircon.
Corhart Refractories Co	Buckhannon, W. Va	Refractories.
Do	Corning, N. Y	Do.
Do	Louisville, Ky	Do.
E. I. du Pont de Nemours & Co	Wilmington, Del	Zircon, foundry mixes.
Foote Mineral Co	Cambridge, Ohio	Alloys.
A. P. Green Refractories Co., Remmey Div	Philadelphia, Pa	Refractories.
Harbison-Walker Refractories Co	Mount Union, Pa	Do.
Harshaw Chemical Co., Inc	Cleveland, Ohio	Oxide, ceramics.
Hercules, Inc., Drakenfeld Div	Washington, Pa	Ceramic colors, milled zircon.
Ionarc/TAFA	Bow, N. H	Oxide.
Lincoln Electric Co., Inc	Cleveland, Ohio	Welding rods.
M & T Chemicals, Inc	Andrews, S. C	Milled zircon.
Magnesium Electron, Inc	Secaucus, N. J	Alloys, chemicals.
NL Industries, Inc., Titanium Alloy Manufacturing Div. (TAM)	Niagara Falls, N. Y	Milled zircon, oxide, alloys, chloride.
Charles Taylor Div	Cincinnati, Ohio	Refractories.
Do	South Shore, Ky	Do.
Norton Co	Huntsville, Ala	Oxide.
Ohio Ferro-Alloys Corp	Brillant, Ohio	Alloys.
Ronson Metals Corp	Newark, N. J	Baddeleyite (oxide).
Sherwood Refractories Co	Cleveland, Ohio	Zircon cores.
Shieldalloy Corp	Newfield, N. J	Welding rods, alloys.
Teledyne Wah Chang Albany Corp	Albany, Oreg	Oxide, chloride, sponge, ingot, powder, crystal bar.
Titanium Enterprises, Inc	Green Cove Springs, Fla	Zircon.
Transelco, Inc	Dresden, N. Y	Chemicals, ceramics.
Union Carbide Corp	Alloy, W. Va. and Niagara Falls, N. Y	Alloys.
Ventron Corp	Beverly, Mass	Alloys, oxide, sponge.
Zedmark, Inc	Butler, Pa	Refractories.
Zirconium Corp. of America	Cleveland, Ohio	Oxide, refractories, ceramics.
HAFNIUM MATERIALS		
AMAX Specialty Metals Corp	Akron, N. Y	Sponge, crystal bar, ingot, scrap.
Do	Parkersburg, W. Va	Oxide.
Babcock & Wilcox Co., Nuclear Materials Div	Leechburg, Pa	Crystal bar.
Teledyne Wah Chang Albany Corp	Albany, Oreg	Oxide, sponge, crystal bar, ingot.

Approximately 2,100 tons of alloys containing 3% to 70% zirconium was produced in 1976.

Three firms produced 27,015 tons of milled (ground) zircon, a decrease of 10% from the reported production in 1975. Six companies, excluding those that produced metal, produced 8,000 tons of zirconium oxide. Oxide production in 1976 decreased from that reported in 1975.

Hafnium crystal bar production was estimated at 30 tons in 1976, compared with 35 tons estimated in 1975.

CONSUMPTION AND USES

Zircon consumption in the United States in 1975 was estimated at 155,000 tons. Consumption of zircon concentrate and milled zircon was 67,000 tons for foundries, 39,500 tons for refractories, 14,000 tons for zirconium oxide, 1,800 tons for zirconium alloys (excluding zirconium-base alloys), and 32,700 tons for all other uses. Foundries consumed approximately one-half of the domestic zircon production; the remaining half was consumed by refractory, abrasive, ceramic, metal, and other industries. Domestic zircon was marketed in proprietary mixtures for use as weighting agents, zircon-TiO_2 blends for welding rod manufacture, and zircon-refractory, heavy-mineral (kyanite, sillimanite, and staurolite) sand blends for foundry sand and sandblasting applications. The zircon-bearing foundry sand was reportedly designed to provide consistent high-quality performance at low cost for critical casting applications.

Table 3.—Zircon consumption in selected zirconium materials as reported by producers in the United States in 1976

(Short tons)

Use	Quantity
Zircon refractories[1]	29,000
AZS refractories[2]	10,500
Zirconia [3] and AZ abrasives[4]	14,000
Alloys[5]	1,800
Foundry aids	67,000
Other[6]	32,700
Total	155,000

[1]Dense and pressed zircon brick and shapes.
[2]Fused cast and bonded alumina-zirconia-silica-based refractories.
[3]Excludes oxide produced by zirconium metal producers.
[4]Alumina-zirconia-based abrasives.
[5]Excludes alloys above 90% zirconium.
[6]Includes chemicals, metallurgical-grade zirconium tetrachloride, sandblasting, welding rods, and miscellaneous uses.

Table 4.—Zirconium oxide[1] [2] consumption in selected zirconium materials as reported by producers in the United States in 1976

(Short tons)

Use	Quantity
AZ abrasives	4,500
AZS refractories[3]	2,400
Other refractories	2,100
Chemicals	800
Glazes, opacifiers, colors	700
Total	10,500

[1]Excludes oxide produced by zirconium metal producers.
[2]Includes baddeleyite.
[3]Fused cast and bonded.

Imported Republic of South Africa baddeleyite ore in 1976 was used principally in the manufacture of alumina-zirconia abrasives and also in ceramic colors, refractories, and for other uses.

Preliminary Bureau of the Census figures for 1976 showed that shipments of zircon and zirconia brick and shapes, composed mostly of these materials, totaled 1.8 million brick, expressed in terms of equivalent 9-inch brick, valued at $13.3 million. In 1975, final figures for shipments were 2.1 million brick valued at $16.7 million.[2]

Zirconium metal was used in nuclear reactors, in chemical plants for corrosion-resistant material, in refractory alloys, and in flashbulbs for photography. Pechiney Ugine Kuhlman Corp., Greenwich, Conn. (a subsidiary of the French firm) and Western Zirconium, Inc., Salem, Oreg. (a group of former Teledyne Wah Chang Albany officials), agreed in principle to manufacture zirconium products in a proposed $30 million to $40 million integrated facility at Dallesport, Wash. The new facility, with construction scheduled to begin in 1977 and startup expected during 1978, will first convert zircon to sponge metal and then semifabricate about 3 million to 4 million pounds per year of the products, plus chemical byproducts.[3]

Zirconium compounds, natural and manufactured, were used in refractories, abrasives, polishes, glazes, enamels, welding

[2]U.S. Bureau of the Census. Refractories. Series MQ-32C, Quarterly, 1976.
[3]Chemical Engineering. News Flashes - Joint Venture Slated for Zirconium Products. V. 83, No. 18, Aug. 30, 1976. p. 55.

rods, chemicals, and sandblasting. Zirconium chemicals were finding increased application in the paint, textile, and pharmaceutical industries. The operating assets of Tizon Chemical Corp. in Metuchen, N. J., a manufacturer of fine zirconia-based polishing materials for the glass and electronic industries, have been acquired by Transelco Co., Inc., Penn Yan, N.Y., and relocated at Penn Yan.[4]

Hafnium metal, alloys, and compounds continued to have few uses. The metal was used for nuclear reactor control rods, in special refractory alloys, and in photographic flashcubes. Nonnuclear hafnium metal uses were reportedly increasing.

Table 5.—Yearend stocks of zirconium and hafnium materials

(Short tons)

Item	1975	1976
Zircon concentrate held by dealers and consumers, excluding foundries	32,312	33,286
Milled zircon held by dealers and consumers, excluding foundries	4,721	4,498
Zirconium:		
Oxide[1]	1,745	663
Sponge	193	259
Ingot	38	66
Scrap	191	146
Alloys	851	539
Refractories	6,495	4,667
Hafnium[e]:		
Sponge and crystal bar	45	40

[e]Estimate.
[1]Excludes oxide held by zirconium metal producers.

PRICES

Published yearend prices for standard grade domestic zircon declined from $257 per ton (1975) to $150 per ton in 1976. Prices for comparable Australian zircon were adjusted downward approximately $25 per ton. Prices for zirconium oxides were either unchanged or unlisted for the entire year. The prices of zirconium chemicals and zirconium sponge, powder, and hafnium metal, sponge, and nitride were unchanged. Zirconium sheet prices advanced slightly. The baddeleyite prices furnished by Ronson Metals Corp. were unchanged from those of 1975.

The Australian Department for Natural Resources again reduced the minimum export prices of zircon sand in bulk, from $A140 to $A115 per metric ton for sand containing 0.1% or more iron oxide; and from $A150 to $A125 per metric ton for sand containing less than 0.1% iron oxide. The new prices apply to new contracts for standard grades of zircon for 1977 delivery, with differentials for premium grade material. These new minimum export prices are generally $A25 per metric ton below the 1976 prices.[5]

At yearend 1974, the spot price for standard-grade Australian zircon was around $A400 per metric ton free in Australian Container Depot (FID). Prices rose rapidly in 1975 when a shortage developed owing to a sharp increase in demand by the Japanese steel industry for zircon-bearing ladle refractories.

[4]Ceramic Age. Transelco Acquires New Corporation. V. 92, No. 5, September-October 1976, p. 5.
[5]Industrial Minerals (London). World of Minerals: Australia— That Zircon Price Confirmed. No. 111, December 1976, p. 9.

Table 6.—Published prices of zirconium and hafnium materials in 1976

Specification of material	Price
Zircon:	
Domestic, standard grade, f.o.b. Starke, Fla., bulk, per short ton[1]	$150.00
Domestic, 75% minimum quantity zircon and aluminum silicates, Starke, Fla., bulk, per short ton[1]	90.00
Imported sand, containing 65% ZrO_2, c.i.f. Atlantic ports, bags, per long ton[2]	135.00
Domestic, granular, 30-ton lots, from works, bags, per short ton[3]	$435.00—440.00
Domestic, milled, 220-mesh, 18-ton lots, from works, bags, per short ton[3]	490.00—495.00
Baddeleyite imported concentrate:[4]	
96% to 98% ZrO_2, minus 100-mesh, c.i.f. Atlantic ports, per pound	.18— .25
99+% ZrO_2, minus 325-mesh, c.i.f. Atlantic ports per pound	.56— .72
Zirconium oxide:[3]	
Powder, commercial-reactor grade, drums, from works, bags, per pound	NA
Chemically pure white ground, barrels or bags, works, per pound	2.22
Lump electric fused, bags, 500 to 1,999-pound lots, from works, per pound	NA
Lump electric fused, bags, smaller lots, from works, per pound	NA
Milled, bags, carlots, from works, per pound	NA
Glass-polishing grade, ton lots, bags, 94% to 97% ZrO_2, from works, per pound	1.11
Opacifier grade, 3,300-pound lots, 85% to 90% ZrO_2, bags, per pound	.81
Stabilized oxide, 100-pound bags, 91% ZrO_2, milled, per pound	1.57
Zirconium oxychloride: Crystal, cartons, 5-ton lots, from works, per pound	.515
Zirconium acetate solution:	
13% ZrO_2, drums, carlots, 15-tons minimum, from works, per pound	.22
22% ZrO_2, same basis, per pound	.38
Zirconium hydride: Electronic grade, powder, drums, 100 to 990-pound lots, from works, per pound	14.50— 16.00
Zirconium:[5]	
Powder, per pound	16.00
Sponge, per pound	5.50— 7.00
Sheets, strip, bars, per pound	10.00— 15.00
Hafnium:[5]	
Sponge, per pound	75.00
Bar and plate, rolled, per pound	120.00
Nitrided, per pound	34.25

NA Not available.
[1]E. I. du Pont de Nemours & Co. Price List (effective 1/1/77). December 1976.
[2]Industrial Minerals (London). World of Minerals-Australia- That Zircon Price Confirmed. No. III, December 1976, p. 9. (Effective 1/1/77).
[3]Chemical Marketing Reporter. V. 210, No. 26, Dec. 27, 1976, p. 42.
[4]Ronson Metals Corp. Baddeleyite Price List. Jan. 1, 1977.
[5]American Metal Market. V. 83, No. 250, Dec. 28, 1976, p. 6.

FOREIGN TRADE

Exports of zirconium oxide increased in 1976 over those of 1975, while exports of zirconium ore and concentrate declined. Exports of wrought zirconium metal and alloys rose in 1976 compared with 1975, but the other forms declined. Hafnium again was not exported.

Zirconium ore and concentrate, exported to 13 countries in 1976, decreased from 37,531,345 pounds valued at $4,786,779 in 1975 to 18,855,595 pounds valued at $2,783,994. The quantity and value exported decreased nearly 50% and 42%, respectively, below that shipped in 1975. The 1975 value was an alltime high. The average value of the zirconium ore and concentrate exported in 1976, $295.29 per ton, represented an increase of $40.21 over the 1975 average value. This increase was attributed more to a larger proportion of higher-priced granular and milled zircon shipped than to the value of the zircon sand. The increased proportion of higher-priced zircon shipped also indicates a return to the normal zircon exporting pattern. The major recipients of the exported zirconium ore and concentrate were Mexico (43%), the Netherlands (17%), Brazil (15%), Canada (12%), West Germany (5%), and the United Kingdom (5%).

Exports of zirconium oxide, which were made to 29 countries, increased from 2,832,128 pounds valued at $2,905,711 in 1975 to 5,325,238 pounds valued at $6,104,200 in 1976. Export quantity increased 88%, and the value more than doubled in 1976. The five major recipients in 1976 were France, (29%), West Germany (22%), Japan (15%), Canada (13%), and the Netherlands (10%).

Total exports of other classes of zirconium decreased more than 13%, from 2,649,694 pounds in 1975 to 2,304,202 pounds in 1976. The value of this material increased about 70% in 1976 to $43,808,525 from the 1975 value of $25,828,888. Of these classes, zirconium and zirconium alloys, wrought, and zirconium and zirconium alloy foil and leaf had increased in both value and quantity in 1975. However in 1976, only the zirconium and zirconium alloys, wrought class, increased in both quantity and value. The unwrought and waste and scrap class decreased 29% in quantity but rose 12% in value. Exports of the foil and leaf class were only 11% of the quantity and 52% of the value of 1975 exports.

Imports for consumption of zirconium ores in 1976 totaled 64,643 short tons, a 61% increase compared with 40,205 tons in 1975. The 1975 figure represented the lowest tonnage of ore imported since 1968 (59,900 tons). Zirconium ore imported from the Republic of South Africa is chiefly baddeleyite (ZrO_2) and, prior to 1974, was reported by the Bureau of Census under a single category listing both quantity and value. This ore is now apparently also imported under a blanket category that reports value only. An estimated 2,000 short tons of South African baddeleyite was imported in 1976.

The average value of imported zircon at foreign ports decreased slightly in 1976 to $212.44 per ton, compared with $220.72 in 1975.

Imports for consumption of zirconium and hafnium in 1976 increased both in quantity and value in the following categories: Zirconium, wrought; zirconium alloys, unwrought and waste and scrap; and hafnium, wrought. Imports for consumption decreased in quantity and value in the zirconium chemicals and zirconium oxide categories. Hafnium in the unwrought and waste category was also imported in 1976.

Table 7.—U.S. exports of zirconium ore and concentrate, by country

Destination	1975		1976	
	Pounds	Value	Pounds	Value
Argentina	253,830	$70,855	393,919	$104,979
Belgium-Luxembourg	--	--	100,429	4,218
Brazil	3,835,500	647,728	2,827,203	1,002,444
Canada	5,241,872	864,061	2,347,886	353,507
Colombia	--	--	8,000	2,235
Germany, West	3,204	1,906	862,304	74,253
Guyana	38,803	700	--	--
Israel	29,893	7,300	--	--
Italy	120,000	20,520	--	--
Korea, Republic of	--	--	135,600	43,419
Mexico	6,839,127	1,025,547	8,136,643	915,708
Netherlands	18,999,028	1,888,890	3,210,689	200,821
New Zealand	--	--	4,000	660
Peru	55,100	12,810	26,422	9,350
Spain	1,760,000	214,400	--	--
Taiwan	53,651	4,970	--	--
Thailand	--	--	2,000	592
United Kingdom	301,337	27,092	800,500	71,808
Total	37,531,345	4,786,779	18,855,595	2,783,994

☆ U.S. Government Printing Office: 1979—281-349/183

Table 8.—U.S. exports of zirconium, by class and country

Country	1975		1976	
	Pounds	Value	Pounds	Value
Zirconium and zirconium alloys, wrought:				
Argentina	--	--	9,427	$100,585
Australia	190	$2,610	382	4,474
Belgium-Luxembourg	74,596	2,437,337	117,251	4,571,126
Brazil	3,485	3,788	90	2,647
Canada	510,568	8,149,651	449,341	8,560,395
France	1,591	23,440	2,883	13,502
Germany, West	439,237	5,003,535	599,480	8,388,128
Italy	3,518	218,863	2,756	102,078
Japan	190,252	4,107,343	536,634	13,077,686
Korea, Republic of	60	1,017	298	5,228
Netherlands	106,200	846,936	21,174	272,081
Norway	2,285	46,347	--	--
Portugal	60	1,450	--	--
South Africa, Republic of	1,621	14,819	102	846
Spain	--	--	2,561	35,684
Sweden	153,508	1,231,877	108,820	1,629,181
Taiwan	--	--	103,625	3,444,617
United Kingdom	106,482	999,011	85,859	1,191,755
Total	1,593,653	23,088,024	2,040,683	41,400,013
Zirconium and zirconium alloys, unwrought and waste and scrap:				
Argentina	2,025	14,900	--	--
Belgium-Luxembourg	1,218	5,518	9,177	62,404
Brazil	44	1,580	--	--
Canada	12,347	187,192	1,333	24,615
Ecuador	11	2,250	--	--
France	58,375	273,268	5,951	69,299
Germany, West	53,907	349,321	36,682	373,525
Indonesia	3,042	7,747	--	--
Japan	52,226	209,146	8,190	76,001
Mexico	160	1,200	--	--
Netherlands	--	--	35,991	419,012
Norway	558	7,034	--	--
Peru	--	--	956	12,926
South Africa, Republic of	506	3,006	--	--
Sweden	23,854	316,301	4,937	83,158
Switzerland	--	--	1,132	10,188
United Kingdom	43,129	261,966	74,142	703,554
Total	251,402	1,640,429	178,491	1,834,682
Zirconium and zirconium alloy foil and leaf:				
Belgium-Luxembourg	4,374	82,488	5,393	97,119
Canada	12,864	208,529	12,317	256,782
France	--	--	315	5,580
Germany, West	3,912	22,083	488	16,155
Ireland	133	4,853	--	--
Italy	2,243	48,490	--	--
Japan	773,184	651,863	61,299	61,299
Netherlands	4,509	17,134	--	--
United Kingdom	3,420	64,995	5,216	136,895
Total	804,639	1,100,435	85,028	573,830

Table 9.—U.S. exports of zirconium oxide, by country

Country	1975		1976	
	Pounds	Value	Pounds	Value
Argentina	48,523	$54,385	146,431	$166,392
Australia	1,493	1,000	5,227	5,048
Austria	--	--	100	806
Belgium-Luxembourg	5,580	6,839	5,396	6,927
Brazil	122,000	129,876	215,022	238,700
Canada	933,608	634,349	671,495	449,904
Dominican Republic	400	750	--	--
France	1,232,173	1,561,435	1,562,642	3,097,169
Germany, West	40,593	49,357	1,184,289	533,140
Greece	--	--	1,000	1,553
Hong Kong	--	--	3,170	6,249
India	--	--	1,000	3,005
Ireland	--	--	408	2,752
Israel	5,299	4,712	1,350	2,442
Italy	96,579	120,707	4,843	8,591
Japan	47,450	52,819	796,994	822,740
Kuwait	--	--	300	552
Mexico	97,784	95,641	145,202	148,415
Netherlands	56,487	72,451	523,278	501,700
Norway	--	--	6,615	27,965
Portugal	--	--	100	2,374
Saudi Arabia	1,000	1,500	--	--
South Africa, Republic of	94	782	1,462	6,142
Spain	--	--	13,331	22,409
Surinam	618	1,500	--	--
Sweden	23,520	22,167	779	522
Switzerland	200	1,476	5,178	4,315
Taiwan	250	1,200	200	3,108
Trinidad and Tobago	--	--	180	2,432
United Kingdom	118,043	92,165	27,244	33,372
Venezuela	434	600	2,000	2,976
Yugoslavia	--	--	2	2,500
Total	2,832,128	2,905,711	5,325,238	6,104,200

Table 10.—U.S. imports for consumption of zirconium ores, by country

Country	1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	59,747	$6,031	36,114	$7,602	62,604	$13,230
Canada[1]	1,054	90	377	61	2,014	492
Christmas Island	--	--	--	--	25	10
India	--	--	2,756	894	(2)	1
Malaysia	1,142	188	440	82	--	--
Mozambique	--	--	22	10	--	--
South Africa, Republic of	7	1	496	225	--	--
Thailand	554	88	--	--	--	--
Total	62,504	6,398	40,205	8,874	64,643	13,733

[1]Believed to be country of shipment rather than country of origin.
[2]Less than 1/2 unit.

Table 11.—U.S. imports for consumption of zirconium and hafnium, 1976

Country	Pounds	Value
Zirconium, wrought:		
France	169,827	$1,758,717
Germany, West	3,961	40,186
Total	173,788	1,798,903
Zirconium, unwrought and waste and scrap:		
Canada	102,749	99,742
France	20,916	11,231
Germany, West	120,390	183,907
Japan	492,583	2,786,938
Sweden	14,335	55,849
United Kingdom	37,183	43,259
Total	788,156	3,180,926
Zirconium alloys, unwrought:		
France	29,457	339,625
United Kingdom	5,000	9,319
Total	34,457	348,944
Zirconium oxide:		
France	56	630
Germany, West	2,252	10,299
Switzerland	181	8,084
United Kingdom	41,889	38,546
U.S.S.R.	88,096	108,609
Total	132,474	166,168
Zirconium compounds:		
Australia	396,936	40,757
France	146,398	92,558
Germany, West	1,945	30,347
Netherlands	3,161	2,696
South Africa, Republic of	269,490	68,760
Switzerland	11	536
United Kingdom	1,010,817	917,841
Total	1,828,758	1,153,495
Hafnium, unwrought and waste and scrap: Japan	59	4,745
Hafnium, wrought: Singapore	3,211	25,527

WORLD REVIEW

Australia leads the world in production of zircon, which is recovered from sand mining operations along its eastern coast (68%) and in Western Australia (32%). Production of zircon, a coproduct of rutile in east Australia, is expected to remain relatively constant due to lower grades and reserves coupled with persistent environmental problems. However, substantial zircon reserves with coproduct ilmenite have been located in Western Australia that, when fully developed, will assure Australia's continuing role in the world zircon markets.

Zircon sand is also produced in Brazil, the People's Republic of China, India, Malaysia, the Republic of South Africa, Spain, Sri Lanka, Thailand, and the U.S.S.R.

Baddeleyite is produced in the Republic of South Africa and Brazil and also is found in east Africa, Sri Lanka, and the U.S.S.R.

Australia.—The Federal Government acted to implement the recommendations of the Fraser Island Environmental Inquiry by prohibiting exports, effective December 31, 1976, of mineral sands (zircon and rutile) from Fraser Island, which lies off Maryborough on the Queensland coast.[6] This export ban would effectively end mining on the island. The company most affected by the decisions was D. M. Minerals (DM), whose processing facility was entirely dependent on the island's raw material. The other company, Queensland Titanium, Ltd., was less seriously affected since its mainland processing plant was also fed by other sand operations. DM is a joint-venture of the U.S.-owned Dillingham Corp. and the Australian Murphyores Holdings; Queensland Titanium is a subsidiary of NL Industries.

The Canadian Ionarc Smelters, Ltd., its subsidiary, Ionarc/TAFA Inc., Bow, N. H., and Associated Minerals Consolidated, Ltd. (AMC), have formed an operating company to produce zirconium dioxide directly from AMC's zircon, using Ionarc's unique

[6]Industrial Minerals (London). World of Minerals: Australia— Fraser Island Sand Bar. No. 111, December 1976, pp. 9-10.

Table 12.—Zirconium Concentrate: World production, by country[1]

(Short tons)

Country	1974	1975	1976[p]
Australia	405,399	421,292	461,227
Brazil	2,776	3,224	[e]3,300
India[e]	11,400	11,400	11,400
Korea, Republic of	44	[r,e]22	--
Malaysia[2]	3,035	11,417	3,449
South Africa, Republic of	[r]13,203	12,780	12,403
Sri Lanka	23	43	11
Thailand	2,207	422	61
United States	W	W	W
Total	[r]438,087	460,600	491,851

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]No data are available on production, if any, within the centrally-planned economy nations, nor is there any basis for the formulation of reliable estimates of output levels.
[2]Exports (production not officially reported; exports believed to closely approximate total output).

plasma-arc technique.[7] AMC also established a zirconium silicate opacifier plant at its Southport works near Brisbane.[8] The plant planned to treat zircon from its Dunwich operation on North Stradbroke Island. In another action, AMC merged with Western Titanium Ltd., a fellow member of the Gold Fields Group.[9] The two companies have a combined production capacity of 170,000 tons of zircon per year.

In Western Australia, Western Titanium completed its mineral sand mining and concentration complex near Eneabba on schedule and started plant commissioning.[10] Shipments were targeted at yearend from its yet incomplete handling facilities at the port of Geraldton. The cost for this complex was estimated at $18.5 million. The AAR group has taken a 50% interest in the holdings of International Nickel Australia in its Eneabba mineral sands prospect,[11] and Westralian Sands Ltd. resumed full-scale mining operations, on standby since November 1975, at its Yoganup beach sand deposit.[12]

Bangladesh.—A feasibility study, including the calculation of ore reserves, assessments of likely products, market studies, preliminary process definitions, and cost studies of beach sand deposits, near Cox's Bazaar, was to be made by the Australian Mineral Development Laboratories (Amdel).[13]

Canada.—AMAX Incorporated and Ontario Hydro abandoned, as uneconomic, plans to construct an integrated plant (zircon-sponge metal-semifabricated products) after an exhaustive study. The project had the backing of experienced metal producers and major customers.[14]

India.— Amdel, in another sand project, was to define a process for a mineral sand operation in Kerala State.[15] The project, on the Arabian Sea, was to include order-of-magnitude capital cost estimates and operating cost estimates.

Sierra Leone.— Sierra Rutile, Ltd., partially owned by Nord Resources Corp., was proceeding with development of its mineral sands deposit at Gbangbama, after receiving Government assurances on tax and fiscal matters and of future Government participation in the project.[16] Production engineering studies were being completed and mining equipment orders placed. The mining project was to be financed in part by a $9 million loan from the Export-Import Bank of the United States.

In another mineral sands venture, Bayer-Preussag Mining Group of West Germany brought a pilot plant for recovering rutile onstream at Rotifunk. The trials should show whether the sands containing rutile, ilmenite, and zircon can be mined and processed economically.[17] The deposit is capable of supplying the entire 50,000 tons per year of rutile consumed in West Germany.

South Africa, Republic of.— The R250 million needed for the new mineral sand project at Richards Bay in Natal has been

[7]Mining Journal (London). Zirconium Dioxide Agreement. V. 286, No. 7337, Apr. 2, 1976, p. 269.
[8]Industrial Minerals (London). World of Minerals: Australia— Some Reflections on the AMC-Western Ti Merger. No. 110, November 1976, pp. 9-10.
[9]Work cited in footnote 8.
[10]Mining Magazine (London). Highlights: International News— Australasia—Eneabba Start-Up. V. 135, No. 2, August 1976, p. 155.
[11]Industrial Minerals (London). Company News and Mineral Notes. No. 106, July 1976, p. 51.
[12]European Chemical News. ECN Newsdesk— Newsbriefs. V. 29, No. 752, Sept. 10, 1976, p. 8.
[13]Engineering and Mining Journal. This Month In Mining— News Briefs. V. 77, No. 8, August 1976, p. 126.
[14]Couch, G. R. Zirconium— A Nonprofit Metal Again in 1976. Eng. and Min. J., v. 178, No. 3, March 1977, pp. 141-143.
[15]Work cited in footnote 13.
[16]Engineering and Mining Journal. In Africa— Sierra Leone. V. 177, No. 2, February 1976, p. 133.
[17]Industrial Minerals (London). Company News and Mineral Notes. No. 107, August 1976, p. 51.

secured, and the export of minerals is scheduled to begin in 1978.[18] The project is being developed by Tisand (Pty.) Ltd. and Richards Bay Iron and Titanium (Pty) Ltd. Share capital is held by Quebec Iron and Titanium Corp. (QIT) of Canada (40%), Union Corp. Ltd. (30%), Industrial Development Corp. of South Africa (20%), and a local insurance group (10%).

Preliminary work on the mineralized sands concentrated in an 11-mile strip of dunes, north of Richards Bay, began during 1976, with full mine production scheduled for late 1977.[19] Zircon production, estimated at 115,000 tons per year at full capacity, was slated largely for export. The deposit was said to have reserves for 30 years of operation.

Sri Lanka.— Amdel was to provide plant specifications, selection of tenders, on-site supervision, and general consultation for a major plant expansion program of the country's beach sand operations.[20]

Tanzania.— Feasibility studies were underway on the heavy mineral sand deposits located near Mtwara on the southeastern coast.[21] The Titanium State Mining Corp., which made the announcement, described similar deposits found at Pemba Island and Bagamoyo, north of Dar es Salaam.

TECHNOLOGY

Bureau of Mines research efforts were directed toward recovering heavy minerals, including zircon, from ores and waste materials; alternate methods for zirconium/hafnium separation; zirconia in titanium and TZM (Mo-0.5Ti-0.08Zr-0.015C) castings, and developing improved ceramic and optical materials. In heavy minerals ore research, the Bureau, in cooperation with Tennessee Valley Authority geologists, investigated the feasibility of recovering zircon and titanium-bearing minerals from the Snowbird Formation in Tennessee. Samples from gold dredging and sand and gravel operations in northern California were also studied, and physical beneficiation schemes were developed for concentrating the heavy minerals from selected localities. Recyclable zircon concentrate and zircon-periclase mixtures were reclaimed from steel foundry sands and investment casting wastes.[22] The studies on alternate methods for zirconium/hafnium separation have delineated a new solvent-extraction process that uses nontoxic eagents and reagents that are less flammable than those used in presently practiced methods.[23] This technique also appears to create fewer environmental problems. Two additional methods for solubilizing and separating zirconium and hafnium, after an alkaline fusion technique, were also under consideration. Results from the casting studies showed that a fused stabilized zirconia mold wash, when bonded with zirconium acetate and coupled with either zircon or olivine sand, gave satisfactory titanium castings. However, whether castings were of aircraft quality was still to be determined. Preliminary results on the TZM castings indicated that shells with a fused calcium stabilized zirconia innerface gave what appeared to be satisfactory castings. To date, of all nonmetal-faced shells (oxides, silicates, carbides, and silicides), only those faced with fused stabilized zirconia were capable of containing molten TZM without serious mold-metal reaction. The improved ceramics materials research concentrated on developing sialons and zirconias suitable for high-temperature combustion and furnacing operations. The effects of various additives on selected physical properties, such as hardness, sintered density, abrasion resistance, and porosity, were being selectively determined. Ambient data indicated that rare-earth-doped sialons have very high modulus-of-rupture values and the rare-earth-doped, calcium-stabilized zirconia exhibited superior abrasion resistance. A contract was also let for investigating the calcia-stabilized zirconia-alumina system as a potential refractory in coal gasification processes.[24] This work was to emphasize microstructural and phase changes in this system after subjection to temperatures as high as 1,300° C for up to 2,000 hours. A

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[18]European Chemical News. ECN Newsdesk: Japanese— TiO_2 Group to Buy S. African Slag. V. 29, No. 751, Sept. 3, 1976, p. 8.

[19]Industrial Minerals (London). World of Minerals: South Africa— Finances Secured for Richards Bay. No. 107, August 1976, pp. 11-12.

[20]Engineering and Mining Journal. This Month in Mining— News Briefs. V. 177, No. 8, August 1976, p. 126.

[21]Industrial Minerals (London). Company News and Mineral Notes. No. 101, February 1976, p. 50.

[22]Bureau of Mines. Mineral Research and Data Analysis Highlights. V. 2, No. 8, September 1976, p. 29.

[23]Page 17 of work cited in footnote 22.

[24]Georgia Institute of Technology (Atlanta, Ga.). Investigation of the Calcia Stabilized Zirconia-Alumina System. BuMines Contract GO 155189, June 16, 1975; available for consultation in Division of Metallurgy, Bureau of Mines, Washington, D. C.

report on the continuing optical-materials research detailed preparation of spectrally selective solar absorbers by depositing a semiconducting film on a reflective base.[25] Zirconium compounds with the general formula, ZrC(x)0(y)N(z), or similar titanium compounds or pure silicon were applied over a silver film. Recent work has revealed two ways of increasing solar adsorption without appreciably increasing the emittance.

A generalized flowsheet and discussion of the Richards Bay, Republic of South Africa, mineral sands mining and ilmenite smelting complex was summarized.[26] This summary covered the entire operation from the mining by two dredges to the final ilmenite-smelting process. Included also was the separation scheme for recovering zircon, magnetite, ilmenite, and rutile concentrates. The dredge fed a primary Reichert cone concentrator floating plant followed by conventional wet and dry mills, high-intensity magnets and tension separators, and spirals. This article covered all facets of the project, including the history, metallurgical investigations, financing, mining, concentrating, smelting, markets, services, and environmental planning. A more detailed treatment of the Richards Bay beach sand project was offered in another article.[27] A brief state-of-the-art article on wet gravity separation, used extensively in mineral sands processing, was published.[28] The article cataloged recent advances in high-feed-densities and high-capacities, improved pumping and instrumentation, which have provided the new tools necessary for designing efficient, compact gravity circuits. The Bartles Mosely concentrator, capable of recoveries below 15 micrometers, with a throughput capacity of 4 to 6 tons per hour, was also included in the discussion.

A comprehensive study dealt with the role of thermal plasma techniques in meeting the future demand for new raw materials.[29] The study, advocating electric power economy, discussed the thermal fundamentals of thermal processing, including reaction models and heat transfer analysis, as well as different types of reactors, their construction, and several successful applications. An application of particular interest, the plasma dissociation of zircon to zirconia, was included.

A partially stabilized zirconia (PZS) ceramic material of unusual properties was developed.[30] The new, high-performance ceramic reportedly would have great potential where toughness and resistance to thermal attack and temperature were required. Life tests on extrusion dies, an important use for fabricated zirconia products, indicated that this ceramic outlasted conventional dies. Other works on high-performance ceramics on another PZS and an Al_2O_3-ZrO_2 material were also published. In the PZS research, finely divided yttria-stabilized zirconia powders were fabricated into specimens by die-pressing, extrusion, and slip-casting methods, and tested for flexural strength.[31] The investigation showed that the gross pores present in unfired specimens varied with fabrication procedures and persisted in the fired microstructures. It appeared that the ultimate flexural strength of extruded and pressed specimens were limited by residual coarse pores near the surface. However, the pressure-cast specimens, with no apparent internal pores larger than grain, exhibited unusually high flexural strengths. This research should improve the conventional fabrication of these new high-performance ceramics. In the Al_2O_3-ZrO_2 study, the fracture toughness of Al_2O_3 was increased considerably by dispersing a second phase of unstabilized zirconia particles.[32] The toughness of these materials was found to increase when uniform, evenly dispersed ZrO_2 particles with a diameter slightly greater than a theoretically determined critical particle size were added. This concept of using unstabilized ZrO_2 inclusions should be applicable in toughening other ceramics.

Phase relations and thermal expansion in the system HfO_2-TiO_2 were investigated in the 0- to 60-mole-percent TiO_2 region using X-ray diffraction and differential thermal analysis, melting point studies, and dila-

[25]Blickensderfer, R., R. L. Lincoln, and D. K. Deardorff. Reflectance and Emittance of Spectrally Selective Titanium and Zirconium Nitrides. BuMines R I 8167, 1976, 30 pp.

[26]Engineering and Mining Journal. This Month In Mining - Mining of Mineral Sands Will Begin in 1977 at South Africa's Richards Bay. V. 177, No. 6, June 1976, pp. 39-40.

[27]Mining Magazine (London). Beach Sand Project for S. Africa. V. 135, No. 5, November 1976, pp. 425-433.

[28]Engineering and Mining Journal. New Interest Focuses on Gravity Separation. V. 177, No. 6, June 1976, pp. 231-232.

[29]Bonet, C. Thermal Plasma Processing. Chem. Eng. Prog., v. 71, No. 12, December 1976, pp. 63-69.

[30]Industry Week. Emerging Technologies. V. 189, No. 6, May 10, 1976, p. 24.

[31]Ruth, P. H., J. S. Reed, and A. W. Naumann. Fabrication and Flexural Strength of Ultrafine-Grained Yttria-Stabilized Zirconia. Bull. Ceram. Soc., v. 55, No. 8, August 1976, pp. 717-721.

[32]Claussen, N. Facture Toughness of Al_2O_3 with an Unstabilized ZrO_2 Dispersed Phase. J. Am. Ceram. Soc., v. 59, Nos. 1-2, January-February 1976, pp. 49-51.

tometry.[33] This work, in a system of compositions with extremely low coefficients of thermal expansion, related this desirable physical property to microcracking. Refractory oxide-metal eutectics were identified and tabulated in a study along with those reported by other investigators.[34] These oxide-metal composite structures formed by directional solidification of eutectic systems show promise for use in high-temperature structural materials, owing to the additive properties of the oxide and metal phases present, and in electronic application where the highly directional properties of the structures can be utilized. A report presents the experimental results on the photochromic effect in iron-doped PLZT (lanthanum-modified lead zirconate-titanate) ceramics, a new class of ferroelectric materials with high optical transparency in the visible light region and strong electrooptics.[35] Considering the results, a mechanism for the effect was proposed in terms of a photoinduced charge-transfer process between the doped impurity atoms. The photochromic effect in transparent ceramic materials may lead to new types of applications, including optical memory and display devices.

A new approach was outlined to investment casting (a large zircon sand and flour consuming industry) which would result in more pieces per mold, lower pouring temperature, less poured weight per part, and higher metallurgical quality, all at reduced costs.[36] The new approach uses a vacuum to draw the molten metal into the bottom of a mold instead of the conventional top pouring method.

Work on producing zirconium and hafnium by reducing oxide ores was described in a recent patent.[37] A mixture of finely divided ore, sodium hydroxide, and sugar is heated to a predetermined ignition temperature, and the reactants flushed and boiled with water to preferentially leach the waste chemical compounds. This residue is then leached with hydrochloric acid and a hydrocarbon solvent, boiled again with water, and subsequently flushed and dried. This purified material is then smelted to a commercial-grade ingot or powder.

Advanced refractory superalloy materials, such as dispersion-strenghthened alloys and directionally solidified eutectics, will be used to increase the operating life of the new gas turbine engines. These nickel-based superalloys, large consumers of zirconium and hafnium, are presently being subjected to increasingly more hostile environments; research is being conducted toward improved high-temperature coatings to permit burning cheaper liquid fuels derived from coal or, if possible, gaseous fuels from a fluidized bed reactor. Research in this area was highlighted in a review article[38]. Test data presented show that plasma-sprayed zirconia-based ceramic coatings, on suitable bond coatings, provide an effective thermal and/or protective barrier for nickel base alloys. Cyclic tests at elevated temperatures up to 1,000° C were most encouraging. Several new aluminum and titanium high-performance aircraft alloys were developed, including several promising, high-strength aluminum powder alloys.[39] These alloys, all containing zirconium, showed increased tensile properties while retaining excellent corrosion resistance, fatigue resistance, and toughness. A new series of beryllium-titanium-zirconium amorphous or "glassy" alloys, offering lightweight, high strength and excellent stiffness, were produced in pilot quantities.[40] Hafnium-nitride-coated tungsten carbide cutting tool inserts were undergoing extensive field tests.[41] Preliminary results showed that hafnium nitride, with its high temperature hardness, appeared to last twice as long as titanium-nitride-coated inserts.

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[33]Ruh, R., G. W. Hollenberg, E. G. Charles, and V. A. Patel. Phase Relations and Thermal Expansion in the System HfO_2-TiO_2. J. Am. Ceram. Soc., v. 59, No. 11-12, November-December 1976, pp. 496-499.

[34]Briggs, J., and P. E. Hart. Refractory Oxide-Metal Eutectics. J. Am. Ceram. Soc., v. 59, No. 11-12, November-December 1976, pp. 530-531.

[35]Tanaka, K., Y. Hamakawa, K. Wakino, and M. Murata. Photochromic Effect in Fe-Doped PLZT Ceramics. J. Am. Ceram. Soc., v. 59, No. 11-12, November-December 1976, pp. 465-469.

[36]Miska, K. H. Vacuum Investment Casting Conserves Metals, Improves Properties. Mater. Eng., v. 84, No. 4, October 1976, pp. 16-22.

[37]Taylor, P. F. Process for Class IV-B Metals Ore Reduction. U.S. Pat. 3,948,637, Apr. 6, 1976.

[38]Mock, J. A. Improving Gas Turbine Performance with Metal and Ceramic Coatings. Mater. Eng., v. 84, No. 5, November 1976, pp. 76-77.

[39]Miska, K. H. Aluminum, Titanium Head New Aircraft, Engine Materials. Mater. Eng., v. 83, No. 4, April 1976, pp. 23-25.

[40]Materials Engineering. Metal News— Glossy Alloys are Light and Strong. V. 83, No. 2, February 1976, p. 29.

[41]Mari, A. Hafnium Nitride Coated Inserts Show Long Life Characteristics. Am. Metal Market/Metalworking News, v. 83, No. 165, p. 28.

Minor Metals

By Staff, Division of Nonferrous Metals

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ARSENIC[1]

Legislation and Government Programs.—The Occupational Safety and Health Administration (OSHA) accepted written comments until July 23, 1976, and held an informal hearing on August 24, 1976, to receive oral testimony regarding an economic and inflation impact statement prepared by OSHA on the proposed standard for occupational exposure to inorganic arsenic. These written and oral submissions were to be used in conjunction with information supplied at 1975 hearings to promulgate emission standards.

An in-depth study for the Environmental Protection Agency (EPA) assembled and interpreted comprehensive information on arsenic and its compounds and the effects of these substances on people, animals, and plants.[2] Another study for EPA assessed the role of arsenic and its compounds in the environment and in the economy of the United States and evaluated the need for and the projected effect of controlling its production, use, dissipation, and emission.[3]

The Puget Sound Air Pollution Control Agency (PSAPCA), in February, granted a 5-year variance from the State of Washington air quality standards to ASARCO Incorporated for operation of its Tacoma arsenic-producing facility.

Domestic Production.—Arsenic trioxide (As_2O_3) was produced domestically only at the Tacoma, Wash., copper smelter of ASARCO Incorporated. Production data cannot be published. Compared with the 1975 figure, output declined 14%, shipments were 5% lower, and stocks advanced 1%. Production of arsenic metal, begun by ASARCO in 1974, continued in 1976.

Consumption and Uses.—Apparent consumption of arsenic, essentially all as white arsenic (As_2O_3), was substantially less than in 1975.

The use of chromated copper arsenate (CCA compounds) in 1975, the latest year for which data are available, was 7,938 tons, an increase for the eigth consecutive year. Consumption of fluor chrome arsenate phenol (Wolman salts and osmosalts) continued to decline; with 584 tons consumed in 1975. Data on consumption of other arsenic compounds, such as calcium and lead arsenate, cannot be published. Small quantities of high-purity arsenic were used in the manu-

[1]Prepared by H. J. Schroeder, physical scientist.

[2]National Research Council, National Academy of Sciences. Arsenic. 1976, 480 pp.

[3]Burruss, R. P., Jr., and D. H. Sargent. Technical and Microeconomic Analysis of Arsenic and its Compounds. Versar Inc., Rept. 454-2, Apr. 12, 1976, 228 pp; available from National Technical Information Service, Springfield, Va., PB 253980.

facture of gallium and indium arsenides for semiconductors.

Prices.—The price of refined white arsenic, 99.5%, at New York docks, quoted at 20 to 23 cents per pound at the start of 1976, decreased to 20 to 21 cents per pound on December 6. Refined white arsenic at Laredo increased from 16.5 to 17 cents per pound on August 8, 1976. The price quotation on arsenic metal at Tacoma advanced from $1.60 to $1.75 per pound on April 1, 1976.

Arsenic metal was quoted in £ London at £ 2,175 per metric ton with advances to £ 2,400 on April 14, to £ 2,550 on July 15, to £ 2,750 on September 30, and to £ 2,950 on December 16.

Foreign Trade.—Imports of white arsenic slumped to only 35% of the 1975 level owing to negligible imports from Sweden, historically the principal supplier. Mexico became the dominant supplier of white arsenic imports, accounting for 89% of the total. All of the arsenic acid (39,628 pounds) came from West Germany; and all of the arsenic sulfide (550,273 pounds) was received from Sweden; 37,478 pounds of sodium arsenate came from the United Kingdom, and 1,684 pounds came from West Germany. Of the 80,831 pounds of other arsenic compounds imported in 1976, 77,161 pounds came from France, 3,393 pounds came from the United Kingdom, 165 pounds came from Switzerland, and the remaining 112 pounds came from West Germany, the Netherlands, and Japan.

Arsenic metal imports totaled 288 tons, only one-half the 1975 level. Sweden supplied 269 tons, Canada 13 tons, and West Germany 4 tons. Smaller quantities were received from Japan, the United Kingdom, the Netherlands, and Belgium-Luxembourg.

Tariff.—Arsenic oxide (white arsenic) enters the United States duty free. A duty of 2 cents per pound was applicable to arsenic metal.

Table 1.—U.S. imports for consumption of white arsenic (As_2O_3) content, by country

Country	1974		1975		1976	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Belgium-Luxembourg	--	--	--	--	1	$1
China, People's Republic of	--	--	--	--	2	1
France	480	$90	595	$261	462	163
Germany, West	--	--	6	5	(1)	4
Mexico	6,185	1,034	3,174	913	3,793	1,354
Peru	24	1	66	11	--	--
South Africa, Republic of	145	29	--	--	--	--
South-West Africa, Territory of	--	--	970	252	--	--
Sweden	6,889	1,284	7,172	2,973	3	4
Switzerland	--	--	30	11	--	--
United Kingdom	19	11	--	--	1	1
Total	13,742	2,449	12,013	4,426	4,262	1,528

[1]Less than 1/2 unit.

Table 2.—U.S. imports for consumption of arsenicals, by class

(Thousand pounds and thousand dollars)

Class	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
White arsenic (As_2O_3)	27,484	2,449	24,027	4,426	8,524	1,528
Metallic arsenic	1,414	3,651	966	2,716	575	1,735
Sulfide	(1)	(1)	(1)	(1)	550	110
Sodium arsenate	266	52	1	5	39	17
Arsenic acid	--	--	(1)	1	40	67
Arsenic compounds n.e.c.	85	55	152	90	81	57

[1]Less than 1/2 unit.

Table 3.—White arsenic (arsenic trioxide):[1] World production by country

(Short tons)

Country[2]	1974	1975	1976[p]
Brazil	[r]20	14	[e]10
France[e]	9,000	9,000	9,000
Germany, West	401	[e]440	[e]440
Japan	213	66	66
Korea, Republic of	18	[r e]110	782
Mexico	10,477	6,747	4,591
Peru	2,175	1,461	870
Portugal	290	282	306
South-West Africa, Territory of[3]	7,319	7,345	[e]7,700
Sweden	[r]16,190	12,884	7,994
U.S.S.R.[e]	8,050	8,100	8,160
United States	W	W	W
Total	[r]54,153	46,449	39,919

[e]Estimate. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing individual company confidential data.
[1]Including calculated arsenic trioxide equivalent of output of elemental arsenic and arsenic compounds other than white arsenic, where inclusion of such materials would not duplicate reported white arsenic production.
[2]In addition to the countries listed, Austria, Belgium, the People's Republic of China, Czechoslovakia, East Germany, Finland, Hungary, Southern Rhodesia, United Kingdom, and Yugoslavia have produced arsenic and/or arsenic compunds in previous years, but information is inadequate to make reliable estimates of output levels.
[3]Output of Tsumeb Corp. Ltd. only.

Technology.—Results of a study to determine any potential arsenic contamination of a proposed reservoir by geothermal springs were published.[4] The study concluded that the effect of the arsenic on the water quality of the reservoir would be minimal.

Research was reported on the effect of four arsenicals — cacodylic acid, cacodylate acid plus sodium cacodylate, arsenic trioxide, and arsenic pentoxide — on the survival of exposed meadow katydids. Life expectancies were reduced to less than 10% of unexposed populations by levels above 5 micrograms of arsenic per gram dry weight in dosing formulations.[5]

CESIUM AND RUBIDIUM[6]

Domestic Production.—There was no domestic production of cesium- or rubidium-bearing minerals during 1976. Cesium and its compounds were produced from imported cesium ore (pollucite). ALKARB, a residue from the processing of lithium ores in previous years, and lepidolite were the sources of domestically produced rubidium and its compounds.

Total production of cesium and rubidium chemical compounds increased 13% and 20%, respectively, compared with 1975 levels. No production of cesium or rubidium metal was reported, but small quantities of both metals were shipped from stocks.

The following companies were the major sources of cesium and rubidium chemicals: Kawecki Berylco Industries, Inc., Revere, Pa.; Kerr-McGee Corp., Trona, Calif.; and Great Western Inorganics, Inc., Golden, Colo.

Consumption and Uses.—Definitive data pertaining to consumption and end use distribution of cesium and rubidium metals and compounds were not available. However, these materials found commercial application in the manufacture of pharmaceuticals, ultracentrifuge separation of organic compounds, and electronic apparatus such as scintillation counters, photomultiplier tubes, and photoelectric cells. Cesium, rubidium, and their compounds can be substituted for each other in some end uses.

While there were no large-scale commercial uses for cesium, cesium metal and compounds have been used in experimental magnetohydrodynamic (MHD) power generators. If MHD electrical generation is successfully developed, demand for cesium may increase.

Prices.—The American Metal Market quotation for cesium metal, 99+% purity, remained unchanged at $100 to $375 per pound. At yearend Metal Bulletin quoted the nominal price for pollucite concentrates containing a minimum 24% Cs_2O, f.o.b. source, at $12.40 to $13 per metric ton unit (22.046 pounds of Cs_2O). No prices were published for rubidium metal.

[4]Middelburg. R. F. Occurrence of Arsenic in the Dry Creek Basin, Sonoma County, California. U.S. Geol. Survey, Water-Resources Investigations 76-30, May 1976, 17 pp.
[5]Watson A. P., R. I. Van Hook, and D. E. Reichle. Toxicity of Organic and Inorganic Arsenicals to an Insect Herbivore. Environmental Sci. & Technol., v. 10, No. 4, April 1976, p. 356.
[6]Prepared by Keith L. Harris, physical scientist.

Table 4.—Prices of selected cesium and rubidium compounds in 1976

Item	Base price per pound[1]	
	Technical grade	High-purity grade
Cesium bromide	$28	$65
Cesium carbonate	29	67
Cesium chloride	30	68
Cesium fluoride	35	75
Cesium hydroxide	35	75
Rubidium carbonate	45	75
Rubidium chloride	46	76
Rubidium fluoride	51	83
Rubidium hydroxide	51	83

[1]Excludes packaging cost, 50- to 100-pound quantities, f.o.b. Revere, Pa.

Source: Kawecki Berylco Industries, Inc.

Foreign Trade.—Pollucite import data were not available. However, reported receipts by consumers indicated that pollucite was imported. Imports of cesium compounds increased from 3,156 pounds valued at $136,203 in 1975 to 4,506 pounds valued at $197,553 in 1976. No cesium or rubidium metal was imported during the year.

Table 5.—U.S. imports for consumption of cesium compounds in 1976, by country

Country	Cesium chloride		Cesium compounds, n.s.p.f.	
	Pounds	Value	Pounds	Value
Germany, West	1,797	$78,830	2,389	$108,955
United Kingdom	308	8,671	12	1,097
Total	2,105	87,501	2,401	110,052

World Review.—The Tantalum Mining Corp. of Canada, Ltd., the major world source of pollucite, made no pollucite shipments from its Bernic Lake, Manitoba, Canada, property during 1976. Late in the year, the Canadian Government placed cesium in all forms on its export control list, banning exports of all cesium-containing materials to any centrally planned economy countries.

GERMANIUM[7]

The new use of germanium as a substrate material for gallium arsenide-phosphide light emitting diodes compensated for the gradual decline in consumption of germanium in semiconductor devices.

Domestic Production.—The only primary producer of germanium in the United States was Eagle-Picher Industries, Inc., of Quapaw, Okla. Much of its output was derived from zinc smelter residues stockpiled in past years from treatment of concentrates from the Kansas-Missouri-Oklahoma district. These residues were supplemented by secondary material from waste and from scrap produced in the manufacture of electronic components and semifabricated shapes.

Other producers of germanium using imported metal, oxide, and scrap or domestic secondary materials were Kawecki Berylco Industries, Inc., Revere, Pa.; Atomergic Chemetals Corp., Plainview, N.Y.; and Texas Materials Laboratory, Garland, Tex.

Production of germanium from domestic sources during 1976 was estimated to be 32,000 to 40,000 pounds. The value of domestic production was approximately $5 million, based on the producer price for refined germanium.

[7]Prepared by John M. Hague, physical scientist.

Consumption and Uses.—During 1976 the use of germanium increased in light-emitting diodes made from heteroepi wafers with gallium arsenide phosphide epitaxial deposits on germanium substrates. Two companies, Texas Instruments, Inc., and Texas Materials Laboratory, announced that they could supply such material for use in digital calculators and digital watches. This development compensated somewhat for the continued decline in use of germanium in conventional types of semiconductors such as transistors and signal diodes. Several manufacturers of power transistors believe that germanium is superior to silicon for heavy-current semiconductors, and they foresee a growing market for such devices. Another use that may become important is in glass fiber light guides, which are likely to find applications in urban communications systems. Germanium was in increased demand for infrared optical systems. Forward-looking infrared detection devices (FLIR systems) often contain several large germanium lenses. Contracts for programs using these instruments were awarded in 1976 and were expected to extend into 1977. Nuclear radiation detectors consumed a small fraction of the germanium supply. Other uses included glass microscope lenses, fluorescent lamps, experimental catalysts, and alloys for brazing and soldering materials.

The estimated distribution of consumption by classes was about 65% in electronic components and accessories, 25% in optical instruments and lenses, 3% for research, and 7% for other uses.

Prices.—The prices of domestic zone-refined germanium and domestic germanium dioxide were $293 and $167.50 per kilogram, respectively, from 1970 through 1976. Prices for imported germanium, quoted as a New York dealer price in Metals Week, have been $330 per kilogram for metal and $174.50 for germanium oxide since March 3, 1975.

Foreign Trade.—U.S. imports of germanium metal (unwrought, waste and scrap) totaled 7,600 pounds in 1976, less than half the quantity imported in 1975. West Germany and the U.S.S.R. were the leading suppliers. The value per pound of imports from Belgium-Luxembourg was high, probably because the Belgian material was high-purity single crystal, whereas other imports were partly concentrates or scrap.

Table 6.—U.S. imports for consumption of germanium in 1976, by country

Country	Quantity (pounds)	Value
Unwrought, and waste and scrap:		
Belgium-Luxembourg	830	$643,907
Germany, West	4,171	184,402
Japan	21	507
Netherlands	663	32,536
Switzerland	8	439
U.S.S.R.	1,914	150,118
Total	7,607	1,011,909
Wrought: Belgium-Luxembourg	39	10,214

World Review.—World production of germanium in 1976 was estimated to be 150,000 to 200,000 pounds, slightly less than in 1975.

Major producing countries reported to have primary sources of supply were the United States, Japan, the U.S.S.R., Zaire, Territory of South-West Africa, and Italy. Other countries with major refining capability were Belgium, West Germany, the Netherlands, and the United Kingdom.

Japan reported production of 35,000 pounds of germanium and 48,000 pounds of germanium oxide. The Kipushi mine in Zaire was the source of germanium-bearing byproducts to be refined in Belgium, but the rate of production at Kipushi in 1976 was less than in recent years.

Technology.—Research continued in 1976 on the future use of germanium in solar cells, superconductors, optical fibers, and antimicrobial organogermanium.

Bell Laboratories and Western Electric Co. were testing an experimental optical communications system in Atlanta, Ga., using optical fibers drawn from quartz tubes after layers of germanium-doped silicon dioxide had been deposited on the inside walls of the tubes.[8]

[8]Chemical and Engineering News. Tests Aim at Fiber Optics Phone System. V. 54, No. 31, July 26, 1976, pp. 17-18.

INDIUM[9]

Domestic Production.—Indium was produced during 1976 by ASARCO Incorporated at its Denver, Colo., plant and by Indium Corp. of America in Utica, N.Y. In May, The New Jersey Zinc Co. and Indium Corp. of America formed a partnership to produce refined indium. The new company, NJZ Alloys, Inc., would use production facilities at the Palmerton plant of New Jersey Zinc, and technical guidance and marketing would be provided by Indium Corp. Other companies, such as Metal Specialties, Inc., in Fairfield, Conn., processed or refined imported material to produce alloys or high-purity metal components and compounds. More than half of U.S. consumption was supplied from domestic production or from stocks, and the balance was furnished by imports and secondary or scrap materials.

Consumption and Uses.—Indium supplies became rather tight in 1976 as demand improved and imports remained at a relatively low level. Demand was estimated to be in the range of 650,000 to 700,000 troy ounces, with 40% being consumed in solders, low-melting alloys, and coatings, 29% in instrument applications and holding devices, 10% in electronic components, and 21% in research and other uses.

Stocks.—Producer stocks continued to decline and at yearend probably represented less than a year's supply.

Prices.—The tight supply situation in 1976 set off a series of price increases. Indium pricing is based on the standard-grade metal, 99.97% pure. During 1975 the price was $5.50 to $6 per troy ounce and it remained at that level until April 1976. As a result of price increases in April, June, August, September, and October, the yearend price was $10 to $10.25 per troy ounce. Higher purity grades, 99.999% plus, sold at a premium.

Foreign Trade.—Imports of indium in 1976 did not return to the high level of the 1970-74 period but were more than twice the small quantity imported in 1975. The value of imports, $1.8 million, reflected the fourfold increase in price during the last 3 years. Canada, Peru, and Japan were the major sources of supply with East Germany moving up to fourth place. No direct imports were reported from the U.S.S.R.

The duty on unwrought, waste and scrap indium has been 5% ad valorem since January 1, 1972, for the most favored nations. Duties on waste and scrap have been suspended until June 30, 1978. The duty on wrought indium was 9%. Statutory duties for the U.S.S.R. and East Germany were 25% ad valorem on unwrought and 45% ad valorem on wrought metal.

[9]Prepared by John M. Hague, physical scientist.

Table 7.—U.S. imports for consumption of indium, by country

(Thousand troy ounces and thousand dollars)

Country	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
Unwrought, and waste and scrap:						
Belgium-Luxembourg	--	--	2	9	(1)	1
Canada	179	542	12	64	76	472
France	--	--	--	--	12	18
Germany:						
East	4	9	--	--	27	174
West	41	97	37	201	--	--
India	--	--	--	--	3	18
Japan	87	600	22	130	50	398
Netherlands	19	58	--	--	16	76
Peru	102	328	21	116	70	476
Switzerland	(1)	5	(1)	3	--	--
U.S.S.R.	--	--	1	2	--	--
United Kingdom	60	259	19	102	20	168
Total	492	1,898	114	627	274	1,801
Wrought:						
Canada	1	8	--	--	(1)	4
Japan	--	--	(1)	(1)	--	--
South Africa, Republic of	--	--	--	--	16	3
United Kingdom	--	--	(1)	2	--	--
Total	1	8	(1)	2	16	7

[1]Less than 1/2 unit.

World Review.—The short supply situation for indium in 1976 was caused by several factors working to reduce world supply. Cominco Ltd., the sole Canadian producer, released only 197,000 troy ounces compared with 224,000 troy ounces in 1975 and 259,000 troy ounces in 1974. ASARCO, one of two U.S. producers, had announced in 1975 that production would be phased down at its Denver plant with intermittent production through 1976 and 1977. The U.S.S.R., which at times has placed large amounts of indium on the market, chose to make no sales to the United States in 1976. Japan, usually an indium exporting nation, had an unexpected increase in demand and imported more than 138,000 troy ounces in 1976. World production was estimated to be about 1.8 million ounces, higher than the 1.5 million ounces in 1975 but lower than the 2.0 million troy ounces estimated for 1974.

Technology.—Polycrystalline indium phosphide films without pinholes were grown on molybdenum sheets using indium and phosphorus trichloride as source materials.[10] Energy use in processing primary indium-bearing materials was estimated in connection with a study of energy use in the production of other commodities by Battelle Columbus Laboratories; the energy required to produce 1 ton of indium metal was estimated to be 509 million British thermal units.[11]

RADIUM[12]

The major use for radium was in therapeutic treatment of cancer. Replacement of radium by other radioisotopes continued.

Domestic Production.—There was no reported radium production in the United States during 1976. Imports, withdrawals from company stocks, and reprocessing supplied sufficient radium to meet the small domestic demand. Radium Chemical Co., Inc., New York, was the main domestic dealer.

Consumption and Uses.—Radium was mostly used in the therapeutic treatment of cancer. A few tens of millicuries of radium were consumed in the production of home alarm smoke detectors. Other uses of radium were as a source of gamma radiation, used in soil moisture density gages and in static eliminators, although polonium-210 was replacing radium. One traditional use of radium, as an illuminator on alarm clocks, was almost completely replaced by tritium; however, at least 24 millicuries of radium-226 was applied to about 1 million timepiece hands and dials. Radium is also used in calibration sources and laboratory standards.

About 900 grams of radium was used in the United States, and around 93 grams was stored in a Government-owned depository in Alabama during 1976. About 48 requests for storage of materials containing a total of 3,500 milligrams of radium were received by the Bureau of Radiological Health, U.S. Department of Health, Education, and Welfare.

Prices.—Radium prices, per milligram unencapsulated, were quoted by Radium Chemical Co. as follows: Less than 100 milligrams, $26.50; 100 to 199 milligrams, $25; 200 to 499 milligrams, $22; and 500 milligrams to 5 grams, $18. There was no change from the 1975 prices.

Foreign Trade.—Official trade statistics did not report trade in radium as such, but included radium with other radioactive commodities. Belgium remained the principal source of imported radium.

World Review.—Information on radium in world markets was not readily available. The largest radium producer and supplier was the Belgian company Union Minière S.A. Small quantities of radium were also apparently produced in Canada, the United Kingdom, and some countries having centrally controlled economies. The industrial nations consumed most of the radium; use patterns were similar to those of the United States.

Technology.—During uranium extraction nearly all the radium remains in

[10]Saitoh, J., S. Matsubara, and S. Minigawa. Growth and Structure of Polycrystalline Indium Phosphide Layers on Molybdenum Sheets. J. Electrochem. Soc., v. 123, No. 3, 1976, pp. 403-406.

[11]Battelle Columbus Laboratories. Energy Use Patterns in Metallurgical and Nonmetallic Mineral Processing (Phase 6 - Energy Data and Flowsheets, Low-Priority Commodities). BuMines Open File Rept. 117(1)-76, 1976, pp. 101-106; available for consultation at the Bureau of Mines libraries in Tuscaloosa, Ala., College Park, Md., Twin Cities, Minn., Rolla, Mo., Boulder City, Nev., Reno, Nev., Albany, Oreg., and Salt Lake City, Utah; at the Central Library, U.S. Department of the Interior, Washington, D.C.; and from National Technical Information Service, Springfield, Va., PB 261 150/AS.

[12]Prepared by M. L. Kahn, physical scientist.

the mill tailings, causing storage and possible environmental problems.

The U.S. Environmental Protection Agency, Nuclear Regulatory Commission, Energy Research and Development Administration, and Bureau of Mines continued studying potential health hazards and possible seepage and erosional problems of radioactive uranium tailings. The radiation level within structures built on reclaimed phosphate lands in Florida was under investigation. The radioactivity of 1,000 structures was to be studied. In addition, the radium-226 content of well water was to be measured, aerial radiation surveys were to be made, and mined phosphate lands in central Florida were to be inventoried and categorized. A 50-foot core sample from an area in Polk County emitting high levels of radiation was obtained for analysis.

A tentative reference method for the measurement of total radium and radium-226 in environmental water sources was described.[13]

SCANDIUM[14]

Minor quantities of scandium were consumed during 1976, mostly in research applications. There was no mine production of scandium, and imports and industrial stocks were sufficient to meet demand. One domestic producer provided the majority of the scandium metal and compounds consumed.

Domestic Production.—In 1976 there was no domestic mine production of scandium. Imports and company stocks of scandium were sufficient to supply domestic demand. There were two major producers of scandium metals and compounds—Research Chemicals, a division of Nucor Corp., Phoenix, Ariz., supplier of about 90% of domestic demand; and Atomergic Chemetals Corp., Plainview, N.Y. During 1976 there was a slight increase in the demand for scandium products, although this demand still totaled only a few tens of pounds.

Consumption and Uses.—Research and development continued to be the major consumer of scandium. In addition, there were three main industrial uses. High-purity scandium metal was a component in special high-intensity mercury vapor lamps used for providing outdoor lighting for events televised in color. These lamps emit an illumination approaching the quality of sunlight. Small quantities of scandium strengthen magnesium alloys. Scandium-46 was used for tracing underground fluid flows in petroleum production. Some scandium was consumed by the chemical and electronic industries.

Prices.—During 1976 the prices of scandium metal and compounds remained stable at the 1975 levels, listed in the following tabulation as quoted by Research Chemicals. Scandium was also available in sheet foil 0.001 to 0.1 inch thick at $22 to $130 per square inch in 1- to 10-square-inch lots.

Metal	Per gram, 1 to 99 grams	Per gram, 100 to 453 grams
Ingots	$10.50	$8.00
Powder	11.50	10.35
Chips	11.50	10.35
Distilled	19.00	15.00
Oxide:		
99.99%	5.00	4.00
99.9%	3.50	2.80
Salts [1]	2.50	2.00

[1]Salts include acetates, carbonates, chlorides, nitrates, and oxalates in most stable, hydrous form produced from oxides of 99.9% minimum purity.

Foreign Trade.—There were no official U.S. foreign trade statistics for scandium. Scandium was included in other minerals and metals statistics, however, scandium trade is believed to be minor. Based on available information, Australia and the centrally controlled economy countries were the principal suppliers of scandium-bearing raw materials.

World Review.—Information on scandium-related activities in foreign countries was not readily available. The industrialized nations were involved in scandium research and used small quantities of scandium in industrial applications.

Technology.—Scandium is used in research and a few industrial applications. Most research is basic and oriented toward study of scandium behavior in different environments. However, some results may lead to uses of scandium in metallurgy and in production of ceramics, catalysts, electronic equipment, light bulbs, nuclear reactors, and radioactive tracers.[15]

[13]Environmental Protection Agency. Measurement of Total Radium and Radium-226 in Environmental Waters. A Tentative Reference Method. EPA 600 4-76 012, March 1976, 37 pp.

[14]Prepared by M. L. Kahn, physical scientist.

[15]Horovitz, A. C., K. A. Gschneider, G. A. Melson, D. H. Youngblood, and H. H. Schock. Scandium—Its Occurrence, Chemistry, Physics, Metallurgy, Biology, and Technology. Academic Press, London, 1975, 525 pp.

In metallurgy, the addition of scandium as an alloying element is effective in strengthening magnesium alloys and in refining the grain size of aluminum and increasing its strength. Scandium spheroidizes graphite much more effectively than rare earths or magnesium in cast iron. The addition of scandium carbide to titanium carbide increases hardness, making this carbide the second hardest material known, exceeded only by diamond. Scandium oxide has better heat resistance and thermal shock properties than conventional materials used in glass compositions for flame spray coatings. In electronics, ferrites containing scandium are used in rapid-switch memory cores, and scandium lowers the magnetic induction of these ferrites by about one-half.

A magnetically controlled switch is used that modulates light passing through a single-crystal yttrium-gallium-scandium-iron-garnet film. It may be used in telecommunications where laser beams are used. Scandium metal is also used as a neutron filter because it is transparent to 2-kilavolt neutrons but stops all other neutrons.

Some recent research results were described in Chemical Abstracts in 1976. A self-destructive gamma ray source for guided-missile guidance systems, containing scandium oxide or tantalum oxide as an active material, was described.[16] Tritides of scandium were found to be useful materials for determining the effects of helium accumulation in metallic solids.[17] A scandium salt was reported to be a satisfactory activatable tracer for evaluating the performance of waste water treatment plants.[18] Release of radioactivity from a scandium tritide electron capture detector used in gas chromatography was studied.[19] Significant tritium buildup in gas chromatography equipment and in the mailing container was reported as a possible health hazard to laboratory personnel.

SELENIUM[20]

Domestic production of selenium from primary materials was 400,600 pounds in 1976, a 12% increase over the 1975 production of 357,700 pounds. Shipments by domestic producers increased 30% to 369,600 pounds of selenium. Producer stocks increased 16% over yearend 1975 stocks to 176,700 pounds. Apparent consumption for the year was 989,800 pounds, the lowest since 1972. Continuing the 1974-76 trend, net imports remained at relatively high levels, accounting for 617,800 pounds, or 62% of apparent consumption for the year. Major new copper byproduct refineries in Amarillo, Tex., and Ndola, Zambia, began production in 1976. Led by Japan, world production increased 8% to 2.8 million pounds.

Legislation and Government Programs.—On May 26, 1976, the General Services Administration (GSA) sold the last lot of 2,500 pounds of selenium from the national stockpile. Bids ranged from a low of $9.05 per pound to the winning bids of $17.015 per pound of selenium. Selenium is no longer a stockpile item and was excluded from the list of proposed new stockpile goals released by the Federal Preparedness Agency on October 1.

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[16]Cohen, M., and J. Fradin. Gamma-Ray Source, Self-Destructive in Aqueous Media. Chem. Abs., v. 84, No. 4, Jan. 26, 1976, p. 444.

[17]Perkins, W. G., W. J. Kass, and L. C. Beavis. Helium-3 Release Characteristics of Metal Tritides and Scandium-Tritium Solid Solutions. Chem. Abs., v. 85, No. 10, Sept. 6, 1976, p. 458.

[18]Craft, T. F., and G. G. Eichholz. The Use of Activatable Tracers in the Evaluation of the Performance of Wastewater Treatment Plants. Chem. Abs., v. 85, No. 18, Nov. 1, 1976, p. 416.

[19]Carlton, W. H., W. E. Braselton, Jr., and E. D. Bransome, Jr. Release of Radioactivity From a Scandium Tritide Electron Capture Detector Used in Gas Chromatography. Chem. Abs., v. 84, No. 4, Jan. 26, 1976, p. 442.

[20]Prepared by George J. Coakley, physical scientist.

Table 8.—Salient selenium statistics

(Pounds of contained selenium)

	1972	1973	1974	1975	1976
United States:					
Production, primary	739,035	795,731	644,055	357,722	400,609
Shipments to consumers	760,653	851,200	670,875	284,479	369,588
Imports for consumption	430,000	553,000	837,191	889,320	811,257
Exports, metal	[e]220,000	[e]264,000	166,206	117,596	193,484
Shipments from Government stocks	13,840	228,689	223,606	6,169	2,470
Apparent consumption	984,493	1,368,889	1,565,466	1,062,372	989,831
Stocks, yearend, producer	160,720	105,950	79,130	152,373	176,742
Producers' price, average per pound, commercial and high-purity grades	$9-$11.50	$9.25-$12.36	$16.53-$19.19	$18-$22	$18-$22
World: Refinery production	2,721,000	2,682,000	2,667,679	2,560,517	2,773,256

[e]Estimate.

Domestic Production.—In the United States in 1976 primary selenium was recovered at three copper refineries; AMAX Copper, Inc., Carteret, N.J.; ASARCO Incorporated, Amarillo, Tex.; and Kennecott Copper Corp., Magna, Utah.

In addition anode slimes recovered from the electrolytic tanks of copper refineries and residues of pollution abatement plants at nonferrous smelters and refineries owned by other foreign and domestic mining companies were shipped to these plants for recovery of gold, silver, selenium, and tellurium.

High-purity selenium and various selenium compounds were produced by primary and other processors from commercial-grade metal.

ASARCO began production of selenium from its byproduct recovery circuit at the new Amarillo, Tex., copper refinery in early 1976. Selenium production continued to be affected by the sluggish copper market and the reduced levels of available slimes. In 1976 the U.S. electrolytic copper refineries operated at about 70% of capacity.

Data on actual recovery of selenium from secondary material were not available, but it has been estimated that in 1976 around 190,000 pounds of selenium were refined from scrap recovered from rectifiers and from xerographic and chemical processes.[21] Part of the scrap supply is reprocessed in Canada and returned to U.S. markets for consumption.

Consumption and Uses.—Apparent consumption of selenium in 1976, consisting of shipments from primary producers, net imports, and stockpile releases, decreased 7% to 989,000 pounds from 1975 and nearly 37% from 1974. The reduced demand for selenium-bearing materials in glass, pigments, specialty steels, and electronic components still mirrored the impact of the 1974-75 recession on construction and manufacturing activity in the U.S. economy during this period. Trends in 1976 suggested the following estimate of selenium purchases and consumption by end use categories: Electronic and photocopier components, 35%; glass manufacturing, 30%; chemicals and pigments, 25%; and other, 10%.

In electronic and photocopier applications selenium is used in semiconductors, photoelectric cells, and calculators, and as the key photoreceptor element in xerography. High-purity grades of selenium are preferred in these applications.

A major consumer of selenium is the glass-manufacturing industry; 0.02 to 0.03 pound of selenium is added per ton of glass to neutralize the green iron discoloration. Dark-colored selenium-bearing environmental glass is used as an energy conservation material in office windows to reduce glare and heat transfer.

The main use of selenium in the industrial chemical field is in cadmium sulfoselenate compounds, which are used widely as yellow and red pigments in plastics, paints, inks, and enamels where long life, brilliancy, light, heat, and chemical stability are required. Selenium is also used as a dandruff treatment and in other pharmaceutical preparations.

Demand for selenium in other end uses included the addition of small amounts of ferroselenium to stainless steel to improve casting, forging, and machining characteristics. There are also minor applications for elemental selenium and selenium diethyldithiocarbamate in the processing of natural and synthetic rubber. Selenium in the form of sodium selenite is added to premixed chicken, swine, and turkey grain feed additives as a nutrient to control diseases and to increase the rate of growth.

Stocks.—The drop in consumer demand for selenium contributed to an increase in

[21]Baltrusaitis V. A. Selenium—Demand Rises From Depressed '75. Eng. and Min. J., v. 178, No. 3, March 1977, pp. 190-191.

U.S. producer stocks. Yearend stock levels of 176,700 pounds were the highest since 1971. Stock levels represent about 2 months' supply at the 1976 rate of consumption.

Prices.—Selenium is usually sold as minus 200-mesh commercial-grade powder containing 97% to 99.94% selenium or as high-purity grade in pellets, sticks, and powder containing 99.95% to 99.99+% selenium. Pellets containing 99.999+% selenium are also available.

Domestic producer prices for commercial-grade selenium remained at $18 per pound, unchanged since May 1974; prices for high-purity grades remained at $21 to $22 per pound, unchanged since January 1975. U.S. and European dealer prices moved approximately in unison during 1976, increasing from a January low of $9.50 for commercial-grade selenium to a high of $20 per pound in late April. Dealer prices held at $17 to $18 per pound from May to October, then declined to $12 to $14 per pound by yearend.

Foreign Trade.—Selenium exports increased 65% over 1975 to 193,484 pounds valued at $2,559,258, with an average value of $13.23 per pound. As shown in table 9, the United Kingdom (35%), Canada (28%), West Germany (9%), and the Netherlands (9%) took delivery of the major share of exports.

Selenium imports for consumption decreased to 811,257 pounds from the record high 1975 level of 889,320 pounds; the value of imports increased 18% to $12,117,580. The average value of unwrought selenium metal imported during the year was $15.06 per pound and for selenium dioxide $12.06 per pound. Canada supplied 43% by quantity and 56% by value, and Japan, 23% and 18%, respectively, of all selenium imported.

U.S. import tariff schedule items 632.40—selenium metal, unwrought, other than alloys, and waste and scrap; 420.40—selenium dioxide; and 420.52—selenium salts, were duty-free at yearend. The duty on Item 420.54, other selenium compounds, was 5% ad valorem.

Table 9.—U.S. exports of selenium in 1976, by country

Country	Quantity (pounds)	Value
Argentina	122	$1,100
Belgium-Luxembourg	9,900	167,358
Bolivia	196	4,402
Brazil	4,200	48,094
Canada	54,715	393,644
France	66	1,764
Germany, West	17,932	301,799
Israel	62	1,264
Italy	9,616	100,043
Japan	3,944	125,830
Mexico	5,732	63,465
Netherlands	17,344	282,773
Spain	1,107	13,284
United Kingdom	67,248	1,038,338
Uruguay	200	4,000
Venezuela	1,100	12,100
Total	193,484	2,559,258

Table 10.—U.S. imports for consumption of selenium in 1976, by country

(Pounds of contained selenium)

Country	Quantity	Value
Unwrought, and waste and scrap:		
Australia	4,409	$47,051
Belgium-Luxembourg	10,917	158,181
Bulgaria	4,519	35,941
Canada	344,108	6,693,351
Chile	31,305	361,769
China, People's Republic of	1,102	17,086
Germany, West	11,404	167,911
Japan	187,999	2,166,873
Mexico	41,269	570,856
Netherlands	7,885	84,729
Norway	26,744	148,255
Peru	2,640	36,535
Sweden	26,687	48,644
Switzerland	19	596
United Kingdom	10,061	277,775
Yugoslavia	68,211	924,175
Total	779,279	11,739,728
Selenium dioxide:		
Belgium-Luxembourg	2,208	24,282
Germany, West	14,402	182,779
Japan	2,205	19,780
Total	18,815	226,841
Salts:		
Germany, West	220	7,123
United Kingdom	143	357
Total	363	7,480
Other selenium compounds:		
Argentina	2,778	39,690
Belgium-Luxembourg	1,100	21,837
Canada	6,963	52,565
Japan	396	7,149
United Kingdom	1,563	22,290
Total	12,800	143,531
Total all forms	811,257	12,117,580

World Review.—Japan continued as the world's leading selenium producer in 1976 with an output of 1,015,000 pounds, followed by Canada with 760,000 pounds. The U.S.S.R. is known to be a major producer, but data are not sufficient to estimate annual production.

Australia.—Peko-Wallsend Ltd. has been Australia's largest producer of gold, bismuth, and selenium since 1973. No selenium production was reported by the company in 1976. The three copper mines and copper smelters at Tennant Creek, Northern Australia, were shut down all year owing to the weak copper market. Of the two gold mines still operating, Juno and Warrego, the Juno was nearly depleted by yearend. Until copper operations resume and underground development work at the Warrego mine is completed, production of recoverable selenium at Tennant Creek is expected to be small.

The only source of refined selenium in Australia continued to be The Electrolytic Refining & Smelting Co. of Australia Ltd. at Port Kembla, New South Wales.

Belgium.—As part of a 5-year expansion program begun in 1974, Metallurgie Hoboken-Overpelt, one of Europe's largest selenium producers, is increasing its selenium production capacity. At yearend its annual capacity was approximately 331,000 pounds.

Canada.—Selenium production from primary raw materials has decreased since 1971 as an increasing amount of copper production from Canadian mines is derived from selenium-poor ores. The major selenium producers, Canadian Copper Refiners Ltd. (CCR) owned by Noranda Mines Ltd. and The International Nickel Co. of Canada Ltd., have annual capacities of 500,000 pounds and 180,000 pounds of selenium, respectively. In 1976 production of selenium in all forms, from Canadian copper refineries, plus refined selenium from domestic primary materials amounted to 760,000 pounds valued at Can$12.2 million, compared with 755,000 pounds valued at Can$13.9 million in 1975. In 1975 Canada consumed

21,900 pounds of selenium domestically, 75% in glass manufacturing and the remainder in steel and pharmaceutical uses.

Japan.—The output of selenium by the six Japanese producers increased 10% in 1976 to 1,014,586 pounds. Stocks at yearend amounted to 205,800 pounds, representing a 17% decrease from 1975.[22]

Zambia.—The new precious metals refinery at Ndola, designed to recover gold, silver, and selenium from copper tankhouse slimes, became operational in late 1976. This is the first African selenium refinery and will recover seleninum from materials previously refined in Europe.

Table 11.—Selenium: World refinery production, by country[1]

(Pounds)

Country[2]	1974	1975	1976[p]
Australia	[3]NA	[3]NA	NA
Belgium[e 4]	[r]155,000	145,000	180,000
Canada[5]	736,233	754,845	[e]760,000
Chile	[e]39,700	26,056	[e]30,000
Finland	21,363	18,689	21,894
Japan	735,390	920,089	1,014,586
Mexico	110,231	127,868	127,868
Peru	17,079	14,744	19,299
Sweden[e]	120,000	100,000	120,000
United States	644,055	357,722	400,609
Yugoslavia	[r]88,628	95,504	[e]99,000
Total	[r]2,667,679	2,560,517	2,773,256

[e]Estimate. [p]Preliminary. [r]Revised. NA Not available.
[1]Insofar as possible, data relate to refinery output only; to avoid double-counting countries are excluded that produce selenium contained in copper ores, copper concentrates, blister copper, and/or refinery residues, but that do not recover refined selenium from these materials indigenously.
[2]In addition to the countries listed, West Germany, the U.S.S.R., and Zambia produce refined selenium, but output is not reported, and available information is inadequate for formulation of reliable estimate of output levels.
[3]The output of Peko-Wallsend Ltd., reported in the previous edition of this chapter as Australian output, has been deleted because it represented the content of intermediate products of metallurgical operations which are treated elsewhere to recover elemental selenium. Australia has one metallurgical facility that can recover selenium (the Port Kembla refinery of The Electrolytic Refining & Smelting Co. of Australia Ltd.), but output, if any, by this facility is unreported and no basis is available for estimation.
[4]Net exports (exports minus imports) plus an estimate for domestic consumption.
[5]Refinery output from all sources, including imported materials and secondary sources.

Technology.—A symposium, Selenium and Tellurium in the Environment, held at Notre Dame, Ind., in May highlighted the continued medical and biochemical research into the essential nature of selenium in animal and human nutrition. Studies indicated that excess exposure to most industrially generated selenium compounds may cause temporary but not lethal toxic effects. More research is required to better understand and to control the possible effects of selenium released into the atmosphere from coal-burning plants and into the groundwater from uranium-processing plants.[23]

The National Academy of Sciences published the results of a study on selenium, giving natural sources and methods of analysis; describing its physical and chemical nature, its biologic effects, and its relation to other pollutants; and discussing margins of safety. The report suggests that selenium is probably not a significant pollution problem but recommends a number of areas where further research is needed.[24]

Results of a study showed that the energy required to produce 1 net ton of selenium powder was equal to 297 million Btu.[25]

[22]Japan Metal Journal. 'Rare Metals' in 1976. V. 7, No. 11, Mar. 14, 1977, p. 5.
[23]Industrial Health Foundation, Inc. Proceedings of the Symposium on Selenium—Tellurium in the Environment. (Univ. of Notre Dame. May 11-13, 1976). Pittsburgh, Pa., 1976, 385 pp.
[24]National Academy of Sciences. Selenium. Medical and Biologic Effects of Environmental Pollutants Series, 1976, 203 pp.
[25]Battelle Columbus Laboratories. Final Report on Energy Use Patterns in Metallurgical and Nonmetallic Mineral Processing (Phase 7 - Summary of the Results of Phases 4, 5, and 6). BuMines Open File Rept. 117(2)-76, Sept. 21, 1976, 31 pp; available for consultation at the Bureau of Mines libraries in Tuscaloosa Ala., College Park, Md., Twin Cities, Minn., Rolla, Mo., Boulder City, Nev., Reno, Nev., Albany, Oreg., Salt Lake City, Utah, and at the Central Library, U.S. Department of the Interior, Washington, D.C; and from National Technical Information Service, Springfield, Va., PB 261 151 1AS.

TELLURIUM[26]

Domestic Production.— Tellurium was recovered domestically as a byproduct of electrolytic copper refining only by AMAX Copper, Inc., at Carteret, N.J., and ASARCO Incorporated, at its newly opened plant at Amarillo, Tex. Commercial-grade tellurium and tellurium dioxide were also produced from the precious- metal-rich anode slimes shipped from other domestic copper refinery tankhouses. High-purity tellurium, tellurium master alloys, and tellurium compounds were produced by primary and intermediate processors from commercial-grade metal and tellurium dioxide. Tellurium production and shipments by producers in 1976 increased relative to the 1975 levels of 131,000 pounds and 163,000 pounds, respectively. Producer stocks dropped from the preceding yearend inventory of 55,000 pounds.

Table 12.—Salient tellurium statistics

(Pounds of contained tellurium)

	1972	1973	1974	1975	1976
United States:					
Refinery production	257,229	240,879	191,324	130,844	W
Shipments to consumers	271,134	286,721	160,162	163,089	W
Imports for consumption	146,128	r79,159	164,344	97,350	203,534
Apparent consumption	417,262	r365,880	324,506	260,439	W
Stocks, yearend, producer	102,121	56,279	87,441	55,196	W
Producers' price: Average per pound, commercial grade	$6	$6.05	$8.34	$9.28	$10.33
World: Refinery production	396,000	446,000	r466,866	314,950	NA

rRevised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

Consumption and Uses.—Apparent consumption of tellurium increased substantially over the 1975 demand of 260,000 pounds. Tellurium consumption by end use in 1976 was estimated as follows: Iron and steel production, 77%; nonferrous metal production, 14%; chemical uses, 5%; and other uses including rubber manufacturing, 4%. Tellurium is used in its elemental state as a free-machining agent in stainless steel and copper production, in the chilling of malleable cast iron, and as a curing agent and accelerator in rubber compounding. Bismuth and lead telluride alloys are used in semiconductor and minor thermoelectric applications. Tellurium is used in the dioxide state in the forming and tinting of glass and as a chemical catalyst. Applications for tellurium are somewhat limited by the relatively small availability of refined material and by price. These factors make tellurium susceptible to substitution, particularly by lead in free-machining applications, where the lead exhibits many of the same properties as tellurium. Selenium and sulfur can substitute for tellurium in rubber compounding, and germanium or selenium also substitute in some semiconductor applications.

Prices.—The U.S. producer price for commercial-grade tellurium was $10 per pound from January through October. On November 1, U.S. producers increased the price to the Canadian producers' level of $12 per pound, which became effective on July 1, and where it remained through yearend. In response to high demand and tight supplies of tellurium, the North American producer price increased to $15 per pound in early January 1977. Dealer prices were reportedly near $20 per pound by yearend.

Tellurium is usually marketed in the form of minus 200-mesh powder or as slabs, tablets, or sticks. Normal commercial grades contain a minimum of 99% or 99.5% tellurium. Further refining through distillation and sublimation processes produces high-purity grades, chiefly for use in semiconductors containing 99.95%, 99.999%, and 99.9999% tellurium.

Foreign Trade.—Tellurium metal imports nearly doubled in 1976 to 182,487 pounds valued at $1,583,375, with an average delivered value of $8.68 per pound. In addition 21,047 pounds of tellurium in compounds was also imported. Canada with 70% and Peru with 26% supplied the major share of all imports. There are no data on tellurium exports.

The U.S. tariff for 1976 on TSUS Item 632.48, tellurium metal, unwrought, other than alloys, and waste and scrap, was 4% ad valorem; the tariffs on TSUS Items 421.90, tellurium compounds, and 427.12, tellurium salts, were 5% ad valorem.

[26]Prepared by George J. Coakley, physical scientist.

Table 13.—U.S. imports for consumption of tellurium in 1976, by country

Country	Pounds	Value
Unwrought, and waste and scrap:		
Canada	121,380	$804,418
Germany, West	1	364
Japan	300	5,861
Netherlands	3,516	46,377
Peru	53,787	675,086
United Kingdom	3,503	51,269
Total	182,487	1,583,375
Compounds:		
Belgium-Luxembourg	11	623
Canada	21,018	158,997
Germany, West	11	856
United Kingdom	7	658
Total	21,047	161,134
Grand total	203,534	1,744,509

World Review.—The United States maintained its position as the world's largest producer and consumer of tellurium. Between 1971 and 1975 domestic production accounted for over half of the reported new refined tellurium in market economy countries. During the same period the United States consumed nearly 80% of this reported world production. Production of tellurium outside the United States was estimated at 200,185 pounds. The other main producing countries were Canada, Japan, and Peru. The U.S.S.R. is known to be a substantial producer of tellurium, but insufficient information is available to estimate production. During the tight supply situation of 1976, the U.S.S.R. reportedly was selling tellurium at premium prices on the open market. In Fiji low gold prices threatened to close the Emperor gold mine. Government and corporate subsidies would be required to continue future gold and byproduct tellurium recovery operations.

Table 14.—Tellurium: World refinery production, by country[1]

(Pounds)

Country[2]	1974	1975	1976[p]
Canada[3]	[r]138,031	90,348	110,000
Japan	57,100	[e]47,000	[e]63,000
Peru	80,411	46,758	27,185
United States	191,324	130,844	W
Total	[r]466,866	314,950	[4]NA

[e]Estimate. [p]Preliminary. [r]Revised. NA Not available. W Witheld to avoid disclosing individual company confidential data.

[1]Insofar as possible, data relate to refinery output only; thus countries that produce tellurium contained in copper ores, copper concentrates, blister copper and/or refinery residues, but that do not recover refined tellurium, are excluded to avoid double counting.

[2]In addition to the countries listed, Australia, Belgium, West Germany, and the U.S.S.R. are known to produce refined tellurium, but output is not reported, and available information is inadequate for formulation of reliable estimates of output levels. Moreover, other major copper refining nations such as Chile, Zaire, and Zambia may produce refined tellurium, but output in these nations is conjectural.

[3]Refinery output from all sources, including imports and secondary sources.

[4]Not totaled because of the exclusion of United States' data owing to company confidentiality.

THALLIUM[27]

Domestic Production.—The only domestic producer of thallium and its compounds was the Globe plant of ASARCO Incorporated at Denver, Colo. The plant recovered thallium as a byproduct from residues of base metal ore smelting, principally zinc. Production of compounds in 1976 was about 50 times greater than in 1975. No metal was produced, but shipments almost doubled over those of 1975.

Uses.—Apparent consumption in 1976 was about 1,800 pounds. The current uses for thallium include low-melting alloys, low-temperature thermometers and mercury switches, additives for altering the refractive index of glass, high-density liquids for sink-float separation of minerals, photosensitive devices, infrared light transmission devices, and as an additive to mercury lamps.

Prices.—The price of thallium in 25-pound lots has been $7.50 per pound since the end of 1957.

Foreign Trade.—U.S. imports for consumption in 1976 were 66 pounds of unwrought thallium, waste and scrap, valued at $799, and 775 pounds of compounds valued at $17,018. The amount of imported metal was 93% less than in 1975.

World Review.—In addition to the United States, Belgium, West Germany, and the U.S.S.R. produced refined thallium metal.

[27]Prepared by V. Anthony Cammarota, Jr., physical scientist.

Table 15.—U.S. imports for consumption of thallium in 1976, by country

Country of origin	Compounds (gross weight)		Unwrought, and waste and scrap	
	Pounds	Value	Pounds	Value
Canada	--	--	2	$387
Germany, West	771	$16,706	--	--
Japan	--	--	64	412
United Kingdom	4	312	--	--
Total	775	17,018	66	799

Minor Nonmetals

By Staff, Division of Nonmetallic Minerals

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GREENSAND[1]

Greensand, which is widely distributed in the Eastern United States, was produced in 1976 only by the Inversand Co., a subsidiary of Hungerford & Terry Inc., near Clayton, N. J. Production and sales information is withheld by the Bureau of Mines.

Raw greensand produced by the company was sold for agricultural use as a soil conditioner. Processed greensand was sold for use as a filter medium for the removal of manganese, iron, sulfide, and other elements from water.

IODINE[2]

The world iodine industry, characterized by short-lived economic cycles, began to recover in 1976 from the surplus supply accumulated in 1975, but greater demand was easily met by withdrawals from stocks. Of the three major market economy countries producing crude iodine, only Japan, by far the largest supplier, increased output over the 1975 level. The output of both the United States and Chile declined in 1976. In all three countries iodine is a byproduct, and therefore is dependent on the primary product. Japanese iodine is processed from natural gas brines, Chilean iodine is associated with the nitrate industry, and U.S. iodine, with bromine. The quoted market price of $2.59 per pound remained stable during 1976, but actual sales were discounted 10% to 20%. Increased U.S. demand for crude iodine was reflected in greater consumption by the major chemical companies, up 20% from that of 1975, and an increase in imports of 22%; furthermore, company inventories decreased 20% during the year.

The small production of The Dow Chemical Co., the only domestic producer, fell significantly from the 1975 level. With the entrance of a new U.S. producer early in 1977, the ratio of domestic supply to demand is expected to change significantly. The new plant near Woodward, Okla., owned jointly by PPG Industries, Inc. and Amoco Production Co., will have a capacity to produce 2 million pounds per year from brines averaging 300 parts per million iodine, which will be the only product of the operation.

Plans to expand iodine operations in Japan were not fully realized in 1976. Although total production increased 2.1% over that of 1975, Japanese plants were not

[1]Prepared by Richard H. Singleton, physical scientist.
[2]Prepared by Sandra T. Absalom, physical scientist.

operating at full capacity, and may not reach capacity in the near future because world demand is being met from excess inventories. The Japanese will be assessing the effect of the new U.S. producer on the world market, as well as the effect of possible release of iodine supplies from the U.S. Government stockpile. Chile's output of crude iodine in 1976 was only about three-fourths of 1975 production; nearly a quarter of this was exported to the United States. The industry is studying possibilities for new markets that would further improve the supply/demand situation.

Legislation and Government Programs.—On December 31, 1976, the U.S. Government strategic stockpile contained 8,011,814 pounds of iodine, the same quantity reported at yearend 1975. The stockpile goal for iodine was changed during the year to 3,333,000 pounds. No iodine disposals were authorized.

The depletion allowance for iodine remained at 14% of gross income, and may not exceed 50% of net income without the depletion deduction.

Domestic Production.—The Dow Chemical Co., supplied a small part of the total U.S. requirement for 1976. A coproduct of bromine, calcium and magnesium compounds, and potash from subterranean brines at Midland, Mich., iodine is recovered by the standard two-step process used by Dow since 1964. Iodine production in 1976 declined from the 1975 level in both quantity and value.

Consumption and Uses.—According to the Bureau of Mines canvass for 1976, approximately 5.3 million pounds of iodine, representing a 20% increase over total iodine consumption in 1975, was consumed by 31 plants in 14 States. Eighteen of these plants, which were located in the leading consumer States of Missouri, New York, New Jersey, and Pennsylvania (in decreasing magnitude of consumption), accounted for 71% of total iodine consumption.

While the canvass information indicates a general consumption pattern, establishing an accurate pattern of demand by end use is difficult because iodine is frequently converted into intermediate compounds and marketed as such before reaching its ultimate end use. Moreover, iodine and iodides used in catalytic and other dissipative processes are not well covered. This situation has been revealed consistently in recent years by import figures that exceeded reported consumption figures; in 1976 iodine imports exceeded reported consumption by 1.2 million pounds. Coupling imports with domestic production and inventory withdrawals, apparent consumption in 1976 was about 7.2 million pounds. Comparision of the results of the 1976 canvass with 1975 figures showed increased consumption of crude iodine for making iodine chemicals in all major categories except one. Following are comparative percentages: Organic compounds, up 9%; total inorganic compounds, up 32%, including potassium iodide, up 72.5%, ammonium iodide, down 7%, sodium iodide, up 28%; and resublimed iodine, up 10%.

The major downstream uses for iodine in 1976 were divided into the following categories: Catalysts for synthetic rubber, 22%; stabilizers (as in nylon precursors), 15%; animal feed supplements (mainly for cattle), 15%; inks and colorants, 14%; pharmaceuticals, 14%, sanitary and industrial disinfectants, 10%; photographic film, 4%; and other uses, 6%. The category "Other uses" includes the making of high-purity metals, motor fuels, iodized salt, smog inhibitors, and lubricants. Iodine also has application in cloud seeding and radio-opaque diagnosis in medicine.

The prospect of expanding demand for iodine appears most promising for catalytic uses. At present, iodine catalysts are used to produce synthetic rubber, stabilized rosin, and tall oil. Proposed new uses for iodine

Table 1.—Crude iodine consumed in the United States

Products	1975			1976		
	Number of plants	Consumption: Thousand pounds	Consumption: Percent of total	Number of plants	Consumption: Thousand pounds	Consumption: Percent of total
Resublimed iodine	6	633	14	6	697	13
Potassium iodide	9	730	17	9	1,259	24
Other inorganic compounds	15	845	19	14	953	18
Organic compounds	21	2,193	50	20	2,389	45
Total	[1]31	[2]4,400	100	[1]31	5,298	100

[1]Nonadditive total because some plants produce more than one product.
[2]Data do not add to total shown because of independent rounding.

catalysts are related to two processes, coal gasification and thermonuclear production of hydrogen, that could provide alternatives to fuel oil. Proven economic feasibility of either process, which may not be achieved for many years, could lead to substantial new demand for iodine. Wider use of iodine as an alternative to chlorine in water purification is also anticipated.

Prices.—The quoted price for crude iodine remained at $2.59 per pound throughout 1976, but actual sales were discounted from 10% to 20%. As the leading vendor of crude iodine in the world market, Japan exemplified this trend in discount sales with total exports for the year averaging $2.14 per pound, 17.5% below the official price and 5% below the average price of $2.28 per pound for Japanese exports in 1975. Although U.S. demand for iodine and iodine compounds in 1976 increased somewhat over that of 1975, and surplus stocks in the United States were decreased about 20%, the continued existence of these inventories plus a new source of U.S. production planned for 1977, combined to exert downward pressure on prices. Higher production costs may have counterbalanced this pressure to some extent, however. The quoted U.S. prices for the element and its primary compounds at yearend 1976, unchanged from yearend 1975, were as follows:

	Per pound
Iodine, crude, drums	$2.59
Resublimed iodine, USP, gran., 100-pound drums, works	$4.00-5.25
Calcium iodate, drums, delivered	3.32
Calcium iodide, 35-pound drums, works	5.98
Potassium iodide, USP, gran., crystals, drums, 1,000-pound lots, delivered	3.76
Sodium iodide, USP, crystals, 300-500 pound lots, drums, freight equalized	5.16
Iodoform, NF, 300-pound drums, f.o.b. works	7.75-14.30

Source: Chemical Marketing Reporter, Dec. 27, 1976.

Foreign Trade.—The quantity and value of crude iodine imported by the United States in 1976 exceeded that of 1975 by 22% and 18%, respectively, but remained below 1974 levels. The average value of imported crude iodine dropped from $2.21 per pound in 1975 to $2.13 per pound in 1976. Of the 6.5 million pounds imported, 90% was from Japan and 10% was from Chile. Although Chilean iodine did not find the ready market in the United States that it traditionally enjoyed prior to 1972 (in 1971 U.S. imports from Chile amounted to 41% of total imports), imports did increase by 81% over those of 1975. Total imports of other iodine compounds, including resublimed iodine, were insignificant compared with crude iodine imports.

Tariff rates were 8 cents per pound on resublimed iodine and 12 cents per pound on potassium iodide. Crude iodine enters the United States duty free.

Table 2.—U.S. imports for consumption of crude iodine, by country

(Thousand pounds and thousand dollars)

Country	1974		1975		1976	
	Quantity	Value	Quantity	Value	Quantity	Value
Chile	1,505	2,972	365	856	661	1,253
Japan	6,465	11,877	4,944	10,865	5,821	12,571
Total	7,970	14,849	5,309	11,721	6,482	13,824

World Review.—*Chile.*—Production of crude iodine dropped in 1976 to 3.1 million pounds, a decrease of 28% from the 4.3 million pounds produced in 1975. Iodine, a byproduct of potassium and sodium nitrates extracted from Chile's caliche deposits, is tied to nitrate production, which decreased 15% in 1976. Because of its dependence on the nitrate industry, Chilean iodine has limited flexibility with respect to supply and demand. With the development of synthetic fertilizers after World War I, the once-flourishing natural nitrate industry has suffered considerably, and gradual obsolescence of the extraction technology has limited production as well. In 1976, Government-owned Sociedad Quimica y Minera de Chile S.A. (SOQUIMICH) produced all reported nitrates and iodine from only three mines and plants: Pedro de Valdivia, Maria Elena, and Victoria. Combined capacity for all three amounted to about 4.8 million pounds per year of crude iodine, but this is expected to decrease as equipment wears out. After realizing a $25 million deficit in 1975, SOQUIMICH abandoned all investment projects to increase production and retained only those that would reduce costs. In 1976, the industry began to operate without the need for subsidies.

Exports to the United States increased by 81% in 1976 to 661,000 pounds, a quantity still well below the 1974 figure of 1,505,000 pounds. About 21% of Chile's iodine production was exported to the United States in 1976; most of the balance went to Western Europe and Latin America.

To support employment objectives, Chile's nitrate/iodine industry is labor intensive, maintaining more than 8,000 workers in caliche processing plants and complementary port operations. While most of the nitrate products are produced at a loss, in 1976 the byproduct iodine showed a profit, costing $0.90 per pound to produce, and selling for $2.26 per pound.

China, People's Republic of.—Although data are not available, it is believed that China consumes about one-fourth the quantity of iodine consumed in the United States. Demand is increasing for iodine for food supplements and catalysts. Domestic production from brines and possibly seaweed appears sufficient to satisfy present needs, with few if any imports required. No exports of iodine from Japan to China were reported in 1976, and figures on Chilean exports for the year are not available; however, any exports to China were probably insignificant.

Indonesia.—About 60,000 pounds of crude iodine was produced during 1976. This represented a decrease of 18% from the quantity produced in 1975. The Government of Indonesia and two Japanese firms, Ise Chemical Industries, Ltd. and Mitsui & Co., are building an iodine operation that eventually will have a productive capacity of 600,000 pounds per year.

Japan.—Japan, the foremost producer of crude iodine for the world market, outproduced its closest competitor, Chile, by nearly five to one in 1976. Although production increased 2.1% over that of 1975, reaching 15.3 million pounds, this total was 7% below the 1972 record of 16.5 million pounds. The softening of world iodine demand, which deteriorated through 1975, led to an accumulation of inventories into 1976; however, during 1976, this trend began to reverse, and reviving demand precipitated inventory withdrawals that were expected to continue through 1977. By 1978, inventories are likely to return to basic reserve levels. Japan increased crude iodine exports in 1976 by 884,000 pounds. Export prices averaged $2.14 per pound, or 17.5% below the quoted market price of $2.59 per pound. Exports to the United States amounted to 48% of the total of 12.2 million pounds of iodine shipped to 36 countries. The nine countries of the European Community bought 36% of Japan's iodine, and other significant markets included Switzerland (4%), Canada (2%), and Poland (1.5%). No iodine exports to the U.S.S.R. were reported for 1976, although in 1975, 3.5% of Japan's export total went to the U.S.S.R.

Ise Chemical Industries, Ltd., which produces more than half of Japan's iodine, clearly dominates the industry. All six producers operate on the Chiba peninsula, the original site of the industry, but only Ise has developed additional resources in other parts of the country. As irreversible subsidence problems caused by removal of the subterranean natural gas brines have forced well closings at Chiba, opportunities to increase industrial capacity are available to Ise, but not to the other producers. However, recent depressed-market conditions have inhibited Ise's expansion plans to the extent that the new Miyazaki plant is operating at only one-fifth of capacity and the proposed enlargement of the Niigata plant was never started.

U.S.S.R.—Soviet iodine production capacity is estimated at 3.8 million pounds per year. No iodine imports from Japan were reported for 1976, although imports of 396,000 pounds were reported for 1975, therefore it is believed that the Soviet iodine industry is operating near capacity.

MEERSCHAUM[3]

Crude meerschaum imported for consumption in 1976 totaled 1,200 pounds valued at $310, or $0.26 per pound, c.i.f. Source of the imports was West Germany. This was the first time since 1967 that the United States imported crude meerschaum from that country. Compared with 1975 data, imports declined 89% in quantity and 98% in value in 1976.

QUARTZ CRYSTAL[4]

Production of cultured quartz continued its upward trend, reaching 849,000 pounds in 1976, which was an increase of 17% over that of 1975. Consumption of cultured and natural quartz increased to more than 349,000 pounds compared with 240,000 pounds for 1975. Exports of cultured quartz climbed to a record 457,000 pounds. Production of finished crystal units rose to 82,730,000 units, more than double 1975 production.

Legislation and Government Programs.— The stockpile goal for natural quartz crystal was reduced to zero in October. This action made 2,372,536 pounds of crystal available for disposal as of December 31, 1976. Sales of stockpile excesses totaled 443,392 pounds in 1976. Some of the material sold from the stockpile was purchased and consumed by fused quartz operations.

Table 3.—Salient electronic- and optical-grade quartz crystal statistics

(Thousand pounds and thousand dollars unless otherwise noted)

	1972	1973	1974	1975	1976
Production of cultured quartz	160	307	529	724	849
Imports of electronic- and optical-grade natural quartz crystal:					
Quantity	65	104	389	NA	NA
Value	$78	$92	$368	NA	NA
Exports of electronic- and optical-grade quartz crystal:					
Quantity	149	287	299	486	645
Value	$1,228	$3,283	$4,398	$5,713	$10,908
Natural:					
Quantity	90	205	166	313	188
Value	$587	$1,933	$1,634	$1,656	$1,626
Cultured:					
Quantity	59	82	133	173	457
Value	$641	$1,350	$2,764	$4,057	$9,282
Consumption of raw electronic-grade quartz crystal	189	249	285	r240	349
Natural	87	99	122	90	159
Cultured	102	150	163	r149	190
Production piezoelectric units, number ... thousands	25,555	27,006	35,541	39,545	82,730

rRevised. NA Not available.

Domestic Production.— The publication, Arkansas Mineral Producers and Production 1976, prepared by the Arkansas Geological Commission, listed three companies as producers of natural quartz crystal: Quartz Processing Co., Hot Springs, Ark., 500,207 pounds; Ocus Stanley, Mount. Ida, Ark., 5,400 pounds; and Terry Mining Corp. Midwest City, Okla., 7,695 pounds. The large quantity produced by Quartz Processing Co., is used primarily as lasca (lump quartz used as a feedstock for growing cultured quartz).

Cultured Quartz production increased from 724,343 pounds in 1975 to 848,688 pounds in 1976. Production was stimulated by the continued interest in citizens band (CB) radios, and in electronic watches. The cultured crystals were produced for domestic and export markets.

The eight producing companies reported consumption of 1,032,284 pounds of lasca.

[3]Prepared by A. C. Meisinger, industry economist.
[4]Prepared by Stanley K. Haines, physical scientist.

The bulk of this material was imported from Brazil but production from Arkansas added to the total.

The eight companies reporting production of cultured quartz were as follows: P. R. Hoffman Co., Carlisle, Pa.; Motorola, Inc., Chicago, Ill.; Bliley Electric Co., Cortland, Ohio; Sawyer Research Products, Inc., Eastlake, Ohio; Thermodynamics Corp., Shawnee Mission, Kans.; Western Electric Co., Inc., North Andover, Mass.; Electro Dynamics Corp., Shawnee Mission, Kans.; and Crystal Systems, Inc., Chardon, Ohio.

Consumption and Uses.— Consumption of raw cultured quartz crystal increased to 190,021 pounds, 28% over the 148,724 pounds consumed in 1975. Natural quartz consumption increased 77% to 159,407 pounds in 1976. Total consumption of natural and cultured quartz was 349,428 pounds.

Production and consumption data for 1976 were derived from reports of 63 operations. There were 37 crystal cutting operations in 17 States. Of the total cutting operations, 22 cut cultured quartz only, 14 cut both natural and cultured quartz, and 1 company cut natural crystal only. Pennsylvania was the leading quartz-crystal-consuming State, followed by Kansas, Illinois, and Massachusetts.

Finished crystal units were produced at 54 operations in 20 States. Oscillator plates comprised 73% of production, followed by filter plates, (22%), and telephone resonators and other uses (5%).

Stocks.—Total stocks of raw quartz crystal (cultured and natural) decreased from 311,556 pounds in 1975 to 281,971 pounds . Of this total, 127,628 pounds was cultured quartz and 156,343 pounds was natural quartz.

Foreign Trade.—Exports of natural quartz from the United States declined 40%, from 313,330 pounds in 1975 to 188,130 pounds. The total value was $1,625,955, a unit value per pound of $8.65, up from $5.29 in 1975. The principal countries of destination were Japan, (53,680 pounds), Hong Kong (30,000 pounds), and Switzerland (21,095 pounds).

Exports of cultured quartz increased 165% to a record 457,410 pounds in 1976. The unit value was $20.29 per pound, a decrease of $3.20 per pound. Japan with 321,369 pounds, Taiwan with 52,294 pounds, and West Germany with 19,883 pounds were the principal receiving countries.

Imports of raw natural quartz crystal, valued at more than $0.50 per pound, decreased from 584,647 pounds in 1975 to 187,243 pounds. This category includes both electronic grade and some lasca or lower quality material. Brazil was the source country for 98% of this material. Imports of quartz valued at less than $0.50 per pound were 961,558 pounds valued at $185,401. Brazil supplied 49%, followed by Mexico (26%), and Canada (25%).

World Review.—*Brazil.*—As in past years, Brazil was the leading world source for electronic-grade and lasca-grade quartz. The high prices for lasca set in 1975 have relaxed slightly but still remain considerably above the 1974 levels.

Hong Kong.—Solider (Hong Kong) Ltd., a subsidiary of Solitron Devices, announced plans to increase output of finished crystal units to 500,000 pieces per year. New equipment is being added to enable the company to process raw quartz crystal through the various stages into finished crystal units.

STAUROLITE[5]

Staurolite is a naturally occurring mineral of uncertain and variable composition, but with the general formula $FeAl_5Si_2O_{12}(OH)$. It occurs as reddish-brown to black opaque crystals with specific gravity of 3.65 to 3.77 and hardness of between 7 and 8 (Moh's scale). Staurolite begins to melt at 2,800° F and has a high rate of thermal conductivity and a low rate of thermal expansion.

Aside from a small rock-shop trade in cruciform-twinned crystals (sometimes called fairy crosses) from some deposits in Georgia, North Carolina, and Virginia that are sold as curios or amulets, all the staurolite in the United States is produced commercially by E. I. du Pont de Nemours & Co., Inc. This staurolite is a byproduct of heavy minerals recovery from beach sand from a glacial age deposit in Clay County, in north central Florida. After caustic scrubbing and drying, the staurolite is removed by electromagnetic separation. This staurolite concentrate, about 77% of which is

[5]Prepared by W. Thomas Cocke, physical scientist.

mineral staurolite with uniformly sized, clean, and rounded grains, may contain minor proportions of various other minerals; but has a nominal composition of 45% Al_2O_3(min.), 18% Fe_2O_3(max.), 3% ZrO_2(max.), 5% TiO_2(max.), and 5% SiO_2. Although originally marketed only for use in portland cement manufacture, it is now being marketed as a specialty foundry sand under the trade name "Biasill," and as a sandblast abrasive under the trade name "Starblast."

Quantitative production data are not released for publication, but the 1976 output of staurolite was 2% over that of 1975. Shipments decreased 21% in tonnage but increased 50% in price per ton over that of 1975.

STRONTIUM[6]

Domestic consumption of strontium on a carbonate basis was estimated at 26,000 short tons in 1976, representing a 73% increase from that of the previous year. Imports of strontium minerals increased 65% from 1975 to 35,711 short tons in 1976. Imports of strontium chemicals, primarily from Canada, increased 73% compared with those of 1975.

Legislation and Government Programs.—Government stockpiles contained 14,408 short tons of nonstockpile-grade celestite at yearend. This material has been declared excess, but legislation authorizing its disposal must be obtained before the material can be released for sale.[7]

Domestic Production.—Strontium minerals have not been produced commercially in the United States since 1959. However, a number of firms produced strontium compounds from imported celestite, a strontium sulfate. Approximately 20,000 short tons of strontium carbonate was produced in 1976 from which about 5,500 short tons of strontium nitrate was processed.

Table 4.—Major producers of strontium compounds, 1976

Company	Location	Compounds
Atomergic Chemetals Co	Carle Place, N. Y	Various compounds.
J. T. Baker Chemical Co	Phillipsburg, N. J	Do.
Chemical Products Corp	Cartersville, Ga	Carbonate.
FMC Corp	Modesto, Calif	Carbonate, nitrate.
King Laboratories, Inc	Syracuse, N. Y	Metal alloys.
Mallinckrodt Chemical Works	St. Louis, Mo	Various compounds.
Mineral Pigments Corp	Beltsville, Md	Chromate, molybdate.
NL Industries, Inc., Tam Div	South Amboy, N. J	Titanates.

Consumption and Uses.—Domestic consumption of celestite on a carbonate basis is estimated at 26,000 short tons, up 73% over that of 1975. Although quantitative information concerning consumption is incomplete, sales of domestically produced strontium carbonate to manufacturers of glass panels for color television picture tubes increased. Strontium nitrate consumption in the manufacture of pyrotechnics appeared to have stabilized.

Miscellaneous applications for strontium compounds included ferrites, greases, ceramics, plastics, toothpaste, pharmaceuticals, paint, electronic components, welding fluxes, and high-purity zinc. Small quantities of strontium metal were produced by research companies.

Prices.—At yearend, prices quoted in the Chemical Marketing Reporter were as follows: Strontium carbonate-technical, bags, carlots, works, 18 to 18.8 cents per pound; strontium nitrate-bags, carlots, works, $24 per 100 pounds (unchanged from 1975). Prices for strontium minerals are usually determined by direct negotiations between buyer and seller and are seldom published. The average value of imported strontium minerals at foreign ports was $41.61 per ton, up $3.40 from 1975.

Foreign Trade.—Imports of strontium minerals totaled 35,711 short tons, a 65% increase from that of 1975. All the material was imported from Mexico and represented a 133% increase over 1975 imports of Mexican celestite. Imports of strontium compounds increased 73% above those of 1975, with 94% of the material coming from Canada. Imports of strontium carbonate were up 74%, and imports of strontium nitrate up 65% over those of 1975. Quantitative data on U.S. exports of strontium compounds were not available.

[6]Prepared by W. Thomas Cocke, physical scientist.

[7]General Services Administration. Stockpile Report to the Congress, October 1976-March 1977, p. 28.

Table 5.—U.S. imports for consumption of strontium minerals,[1] by country

Country	1975 Quantity (short tons)	1975 Value (thousands)	1976 Quantity (short tons)	1976 Value (thousands)
Mexico	15,344	$613	35,711	$1,486
Spain	6,269	213	--	--
Total	21,613	826	35,711	1,486

[1]Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.

Table 6.—U.S. imports for consumption of strontium compounds, by country

Country	1975 Pounds	1975 Value	1976 Pounds	1976 Value
Strontium carbonate, precipitated:				
Canada	5,090,940	$864,950	8,421,573	$1,538,757
China, People's Republic of	22,046	4,886	--	--
Germany, West	2,425	732	464,685	61,513
Japan	--	--	200	403
United Kingdom	--	--	4	451
Total	5,115,411	870,568	8,886,462	1,601,124
Strontium chromate:				
Canada	185,850	136,617	473,382	357,767
Norway	--	--	40,000	19,655
Total	185,850	136,617	513,382	377,422
Strontium nitrate:				
Canada	725,740	166,442	1,178,500	276,065
Germany, West	--	--	22,046	6,738
Total	725,740	166,442	1,200,546	282,803
Strontium compounds, n.s.p.f.:				
Canada	43,700	13,114	81,191	22,622
France	5,181	13,800	2,205	6,562
Germany, West	120,181	59,230	44,862	33,956
Japan	4,409	1,533	21,444	10,283
Total	173,471	87,677	149,702	73,423
Grand total	6,200,472	1,261,304	10,750,092	2,334,772

World Review.—*Canada.*—Kaiser Strontium Products, Ltd,. has shut down its strontium chemicals plant at Point Edward, Cape Breton Island, Nova Scotia.[8] Technical problems and overcapacity in the strontium industry appears to have been the causes.

Spain.—A study is being conducted pertaining to the mining of strontium salts and celestite near Granada.[9]

Turkey.—A large deposit of celestite, with reserves in excess of 4 million tons, is located in the Vivas area.[10] Bilfer Maden Ltd., Sirketi, has an open pit operation capable of producing 10,000 tons of celestite (97% $SrSO_4$) per year. Trial shipments have been made to Japan.

United Kingdom.—The Bristol Mineral Co., Ltd., operators of the Yate celestite deposits, has recently undergone some significant reorganization.[11] In order to raise the capital necessary for expansion, three new investors were brought into the company. Bristol has received a large number of orders, particularly for carbonate, and is hoping to increase production still further. Ninety-five percent of its production is exported.

[8]Industrial Minerals. Company Report Highlights. No. 116, May 1977, p. 14.
[9]U.S. Embassy, Barcelona, Spain. State Department Airgram No. A-5, Feb. 16, 1977, p. 16.
[10]Industrial Minerals. Strontium Shuffle as Kaiser Pulls Out. No. 109, October 1976, p. 43.
[11]Industrial Minerals. Yate Aims at World Markets. No. 111, December 1976, p. 13.

Table 7.—Strontium minerals: World production by country

(Short tons)

Country[1]	1974	1975	1976[p]
Algeria	r e2,000	--	--
Argentina	r331	1,102	e1,100
Canada[e]	60,000	28,000	13,200
Iran[e 2]	330	330	220
Italy	827	e800	e770
Mexico	32,568	16,228	e36,000
Pakistan	400	1,121	756
Spain	9,370	8,818	e8,300
United Kingdom	2,646	2,094	e2,200
Total	r108,472	58,493	62,546

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, West Germany, Poland and the U.S.S.R. produce strontium minerals, but output is not reported quantitatively and available information is inadequate for formulation of reliable estimates of output levels.

[2]Year beginning March 21 of that stated.

Technology.—Globe Union has introduced a lead strontium alloy for use in maintenance-free batteries.[12] The lead strontium system combines the best features of lead calcium and lead low antimony alloys. It exceeds the water loss capability of lead low antimony, without the manufacturing problems inherent in the lead calcium systems.

Kaiser Aluminum has developed an aluminum-silicon alloy containing strontium, which, it is claimed, improves the mechanical strength and ductility of finished castings.[13] The strontium is used in place of sodium.

WOLLASTONITE[14]

Wollastonite is a natural calcium metasilicate, usually white or light-colored, with a specific gravity of 2.87 to 3.09 and a Moh's hardness of 4.5 to 5. Ito 5. It theoretically consists of 48.3% lime combined with 51.7% silica. Wollastonite from selected deposits has found increasing use as an ingredient in ceramic mixes for glazes and enamels and especially for floor and wall tile; in the building industry for the production of mineral wool and cold-setting insulation foams, and as a pigment and extender for paints; as a filling agent for plastics, rubber, and asphalt products; in agriculture as a fertilizer and soil conditioner; and in a wide variety of other applications still being developed.

Wollastonite was produced in the United States in 1976 from the underground mine operated by Interpace Corp., at Willsboro, Essex County, N. Y.; output tonnage was 32% greater than in 1975, and the corresponding total value was 49% higher. Specific output data were not released for publication. The company purchased additional property containing reserves of wollastonite in early 1976 to supply the growing market.[15]

Chemical Marketing Reporter quoted wollastonite prices in bags, carlots, works, at $43.80 per ton for paint grade, fine, and $33.00 per ton for paint grade, medium, unchanged (both quotations) December 1971 through early December 1976. However, the December 13, 1976, issue quoted prices as $124.00 per ton for paint grade, fine, and $107.50 per ton for paint grade, medium. The price range quoted in the December 1976 issue of Industrial Minerals (London) for wollastonite (imported, ground, bagged, c.i.f. main European port) was approximately equivalent to from $114 to $128 per ton.

ZEOLITES[16]

The emergence of markets of sufficient size to make natural zeolite production more than sporadic did not happen in 1976. Several hundred tons, principally clinoptilolite, were mined at various sites, mainly to meet the demand for ammonia removal

[12]Globe Union Inc. Report on the Annual Meeting and Results of the Three Months Ended Dec. 31, 1976. P. 2.

[13]Metal Bulletin. No. 6138, Oct. 29, 1976, p. 26.

[14]Prepared by Michael J. Potter, physical scientist.

[15]Industrial Minerals (London). Company Profile-Interpace Corporation. No. 102, April 1976, p. 55.

[16]Prepared by Robert A. Clifton, physical scientist.

from the effluent of waste water treatment plants.

Prices received for clinoptilolite varied so widely ($160 to $600 per short ton) that no pattern emerged.

About 50 tons of natural chabazite was marketed by Union Carbide Corp. at prices well over $2,000 per ton, and Letcher & Associates offered pelletized, activated, natural chabazite at prices between $1,040 and $1,480 per ton, depending on quantity.

Some applications research into uses for natural zeolites was underway, both in the United States and abroad. The principal market areas being studied were agriculture, aquaculture, and waste treatment.

ZEOLITE '76, an international conference on the occurrence, properties, and utilization of natural zeolites, was held in Tucson, Ariz., in June. The total of 185 engineers and scientists from 21 countries attending the conference was indicative of the great interest in these minerals. The potential markets for natural zeolites were discussed, among other things. It was demonstrated that they can be used as inexpensive, selective ion exchangers and sorbents in direct competition with the synthetic zeolites. Uses foreseen were in the fields of energy development, pollution control, waste recovery, and animal nutrition. A paper that aroused considerable interest demonstrated that clinoptilolite and chabazite can be used to increase the efficiency of solar energy systems.

The synthetic zeolite industry apparently continued to expand, and the emergence of a probable major new market highlighted the year. Both Henkel, G.m.b.H. in Dusseldorf, West Germany, and the Proctor & Gamble Co., in Cincinnati, Ohio, announced new detergent formulations in which half of the phosphate levels would be replaced by synthetic zeolites. Henkel plans to manufacture its zeolite in cooperation with Degussa, G.m.b.H., and market it under the trade name "Sasil." J. M. Huber Corp. will reportedly manufacture the zeolite for Proctor & Gamble in a 50,000-ton-per-year plant; it will sell for about $400 to $500 per ton. Two other companies were reportedly considering new zeolite capacity.

The Bureau of Mines was preparing to initiate a survey to determine the number of potential mines and producers of natural zeolites.